Radiological Health Data

VOLUME V, NUMBER 9

SEPTEMBER 1964

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

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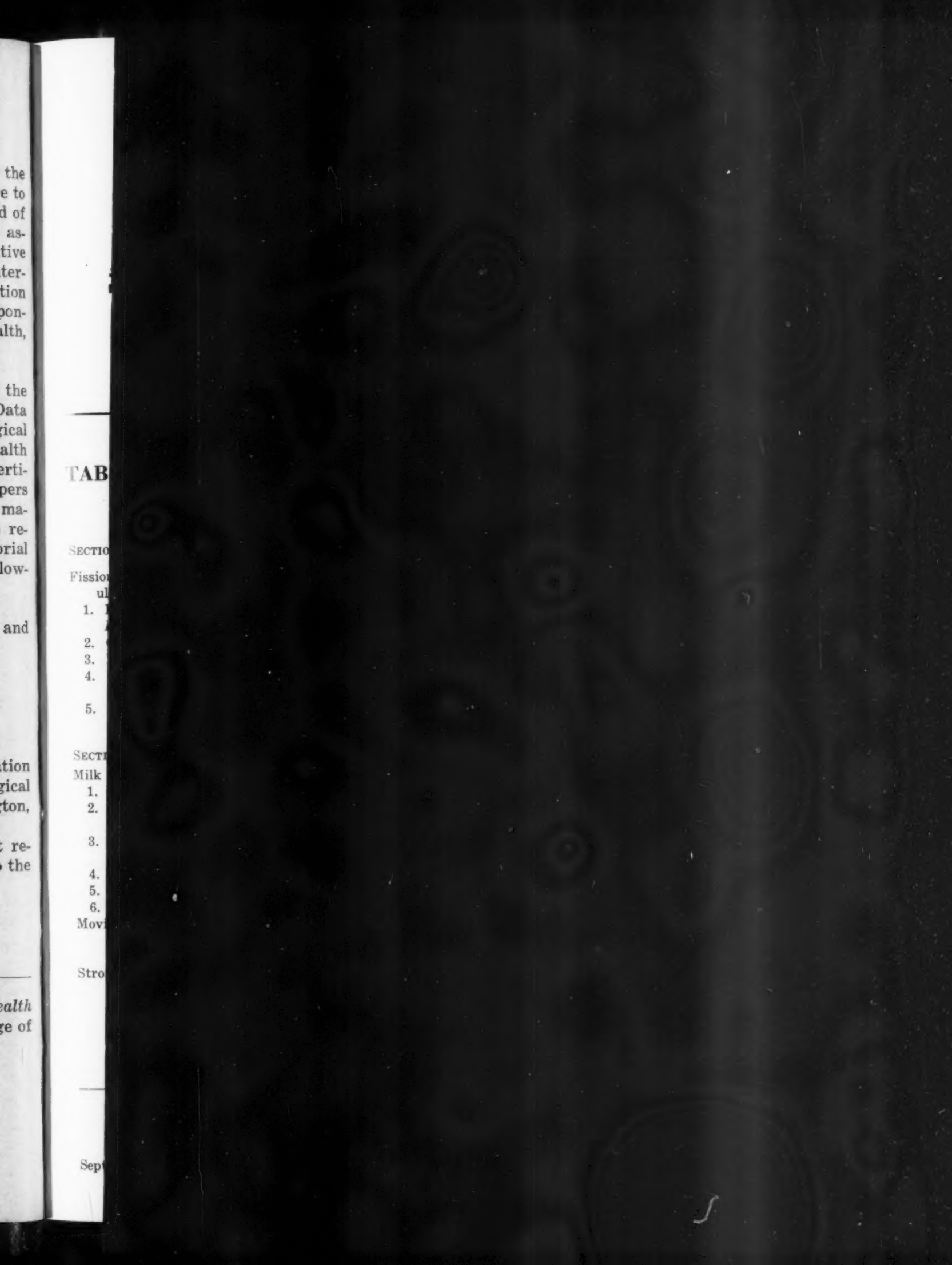

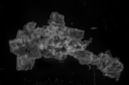

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 5.

1. Radiation Surveillance Network May 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are notified.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated age of selected samples are reported by the PHS in a monthly RSN report (*1*).

The network's highest activity during May was observed on the Salt Lake City, Utah, May 19 sample. The twenty samples with the highest activities during May are listed in table 1, together with their gross beta concentrations.

The May 1964 average gross beta concentration in air for each station is given in table 2. The network average for May (1.94 pc/m^3) showed an increase over both the March and April averages, 1.56 and 1.60 pc/m^3, respectively. The twenty highest samples in May ranged from 5.15 to 8.44 pc/m^3. In April the twenty highest samples ranged from 5.06 to 7.76 pc/m^3.

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

TABLE 1.—GROSS BETA ACTIVITY OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING MAY 1964

Station		Date	Concentration (pc/m^3)
Colo:	Denver	May 4	6.09
		6	8.00
		8	5.55
Idaho:	Boise	19	5.45
		24	5.45
		26	6.77
		27	5.52
Miss:	Jackson	1	5.20
Nev:	Las Vegas	18	7.71
		19	6.91
		21	5.15
N. Y.:	Buffalo	27	5.97
Ohio:	Painesville	19	5.16
Tenn:	Nashville	1	5.84
Utah:	Salt Lake City	19	8.44
Vt:	Barre	4	6.45
		5	5.69
Wyo:	Cheyenne	4	6.87
		5	6.40
		6	5.89

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, MAY 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter) [b]	Total deposition [b] (nc/m²)
			Maximum	Minimum	Average [a]			
Alabama:	Montgomery	20	3.91	0.64	2.01	Aug 64	590	21.7
Alaska:	Adak	29	4.01	<0.10	1.40	Nov 63		
	Anchorage	31	2.31	0.23	0.94	Jul 64	770	15.9
	Attu	29	4.40	<0.10	1.25	Dec 63		
	Fairbanks	22	1.73	0.22	0.92	Aug 64	390	3.8
	Juneau	13	1.84	<0.10	0.86	Sep 64	380	64.1
	Kodiak	17	2.10	<0.10	0.75	Oct 63	[b]	
	Nome	12	1.50	0.14	0.72	Feb 64		
	Point Barrow	26	1.72	<0.10	0.70	Jan 64		
	St. Paul Island	18	2.57	0.47	1.29	Mar 64		
Ariz:	Phoenix	29	4.76	1.39	2.62	Sep 64		
Ark:	Little Rock	30	4.71	0.62	2.11	Sep 64	260	8.2
Calif:	Berkeley	20	1.73	0.42	0.92	Oct 63		
	Los Angeles	21	1.85	0.85	1.38	Feb 64		
Canal Zone:	Ancon	16	0.99	<0.10	0.48	Apr 64		
Colo:	Denver	27	8.00	1.25	2.87	Nov 63	270	19.8
Conn:	Hartford	31	3.74	0.31	1.91	Oct 63	610	20.8
Del:	Dover	18	4.96	0.56	2.62	Aug 64		
D. C:	Washington	29	4.79	0.14	2.69	Aug 64	930	35.4
Fla:	Jacksonville	29	3.87	0.77	2.48	Sep 64	430	17.3
	Miami	29	3.39	0.53	1.74	Feb 64	260	34.2
Ga:	Atlanta	12	2.74	0.20	1.55	Jul 64	290	18.4
Guam:	Agana	31	1.10	<0.10	0.38	Apr 64		
Hawaii:	Honolulu	31	1.83	0.34	0.97	Feb 64	360	3.6
Idaho:	Boise	30	6.77	0.79	2.62	Dec 63	570	29.8
Ill:	Springfield	28	4.16	0.48	1.94	Mar 64	1,100	22.5
Ind:	Indianapolis	31	3.79	0.85	2.20	Jul 64	1,000	35.9
Iowa:	Iowa City	27	4.76	0.25	2.12	Jan 64	520	27.3
Kans:	Topeka	21	4.64	0.45	1.68	Jul 64	700	28.1
Ky:	Frankfort	31	4.26	0.73	2.45	Feb 64	760	24.1
La:	New Orleans	31	2.23	0.50	1.30	Mar 64	980	27.1
Maine:	Augusta	31	4.19	0.14	2.22	Mar 64	520	24.9
	Presque Isle	26	4.38	<0.10	1.60	Nov 63		
Md:	Baltimore	20	4.31	0.17	2.23	Nov 63	650	6.5
	Rockville	7	3.69	1.62	2.33	Mar 64		
Mass:	Lawrence	31	4.88	0.42	2.16	Aug 64	1,200	34.9
	Winchester	29	3.40	0.83	2.05	Apr 64	780	19.4
Mich:	Lansing	31	4.39	0.98	2.63	Feb 64	670	50.3
Minn:	Minneapolis	29	4.66	0.12	1.70	Mar 64	860	73.1
Miss:	Jackson	27	5.20	0.69	2.66	Apr 64	370	9.5
	Pascagoula	9	2.78	0.93	1.76	Dec 63		
Mo:	Jefferson City	31	3.01	0.57	1.67	Jul 64	280	22.9
Mont:	Helena	31	5.12	<0.10	1.79	Nov 63	470	24
Nebr:	Lincoln	4	3.03	1.03	2.04	Apr 64		
Nev:	Las Vegas	26	7.71	1.49	3.82	Aug 64		
N. H:	Concord	20	5.12	0.82	2.67	Feb 64	380	43.9
N. J:	Trenton	31	3.98	0.31	2.14	Apr 64	1,500	2.5
N. Mex:	Santa Fe	23	3.95	0.48	1.62	Dec 63	1,400	26.9
N. Y:	Albany	20	2.81	0.73	1.76	Jul 64	470	11.2
	Buffalo	6	5.97	0.89	3.24	Nov 63		
	New York	19	4.80	0.21	2.28	Dec 63		
N. C:	Gastonia	31	5.11	0.99	2.70	Jan 64	520	4.9
N. Dak:	Bismarck	31	4.33	0.26	2.13	Feb 64	1,100	30.1
Ohio:	Cincinnati	20	4.64	0.73	2.42	Aug 64		
	Columbus	31	4.39	0.59	2.31	Apr 64	770	68.2
	Painesville	31	5.16	0.42	3.08	Oct 63	980	85.8
Okla:	Oklahoma	24	3.52	0.42	1.88	Apr 64	350	16.5
	Ponca City	30	3.06	0.37	1.12	Oct 63	270	32.2
Ore:	Portland	30	4.79	0.22	2.54	Oct 63	350	9.1
Pa:	Harrisburg	31	2.67	<0.10	1.30	Jul 64	800	15.9
P. R:	San Juan	30	2.23	0.35	1.14	Mar 64	500	1.4
R. I:	Providence	26	4.25	0.52	2.48	Jan 64	1,200	15.4
S. C:	Columbia	30	3.85	0.44	2.19	Dec 63	1,100	62
S. Dak:	Pierre	31	4.47	0.31	2.15	Sep 64	400	23
Tenn:	Nashville	29	5.84	0.83	2.65	Jan 64	790	70.8
Tex:	Austin	29	4.17	0.32	1.42	Aug 64	250	12
	El Paso	30	4.95	0.59	2.00	Jan 64	320	2.8
Utah:	Salt Lake City	31	8.44	<0.10	2.30	Aug 63	600	51.5
Vt:	Barre	29	6.45	0.19	3.07	Sep 64	620	36.2
Va:	Richmond	31	4.17	0.17	1.96	Sep 64	710	23.2
Wash:	Seattle	31	2.05	0.15	1.11	Jul 64	1,400	30.7
W. Va:	Charleston	31	4.31	0.64	2.55	Dec 63	1,100	21.5
Wisc:	Madison	29	4.65	0.32	2.43	Sep 64	8.0	97.2
Wyo:	Cheyenne	31	6.87	0.75	2.59	Aug 64	1,100	20.3
Network summary		1817	8.44	<0.10	1.94		603	28.5

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Blank spaces indicate precipitation not sampled.

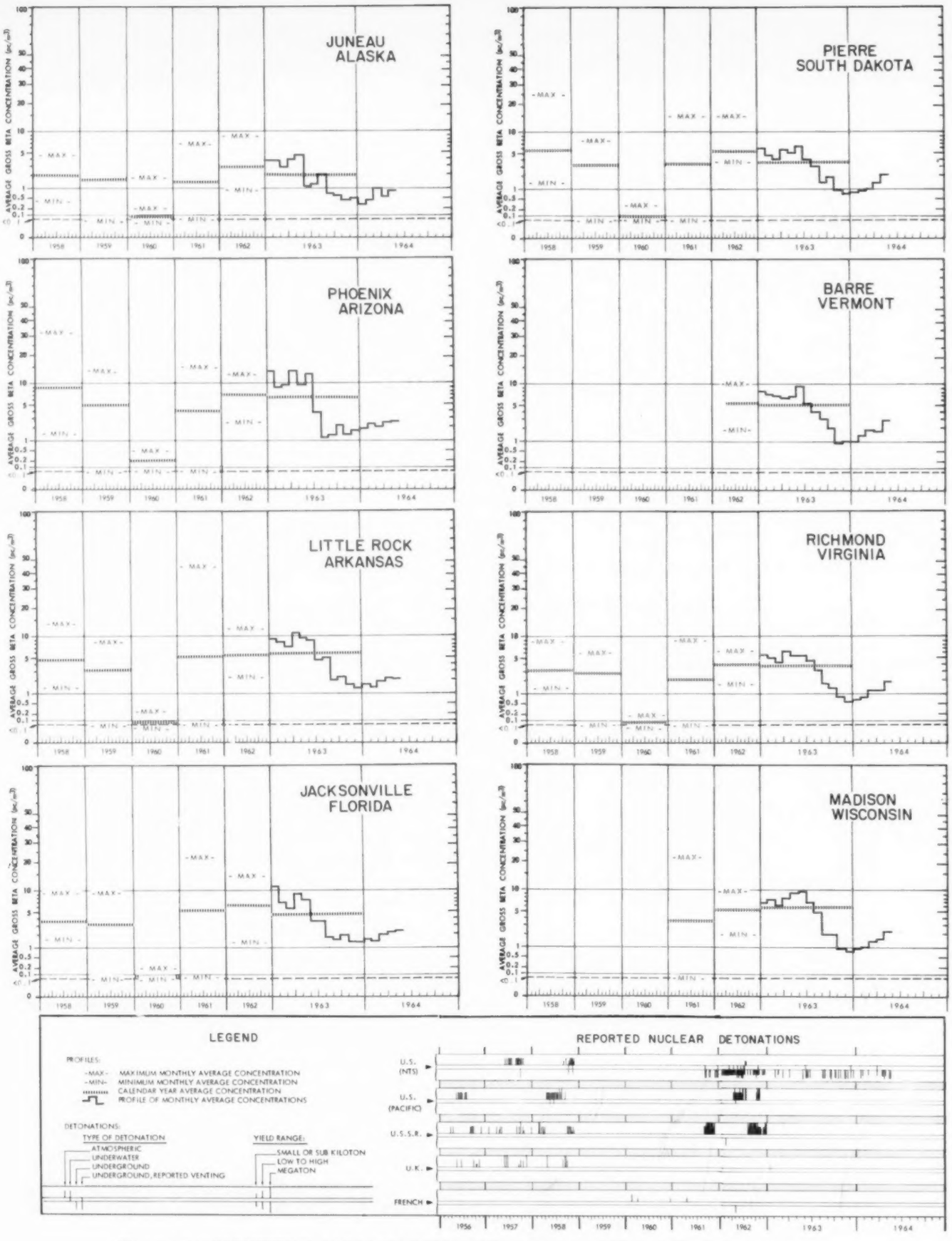

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958—MAY 1964

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The May 1964 average concentrations and total depositions are given in table 2.

2. Canadian Air Monitoring Program[2] May 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for May 1964 are given in table 3 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

[2] Data from *Radiation Protection Programs 6*:11-24, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (May 1964).

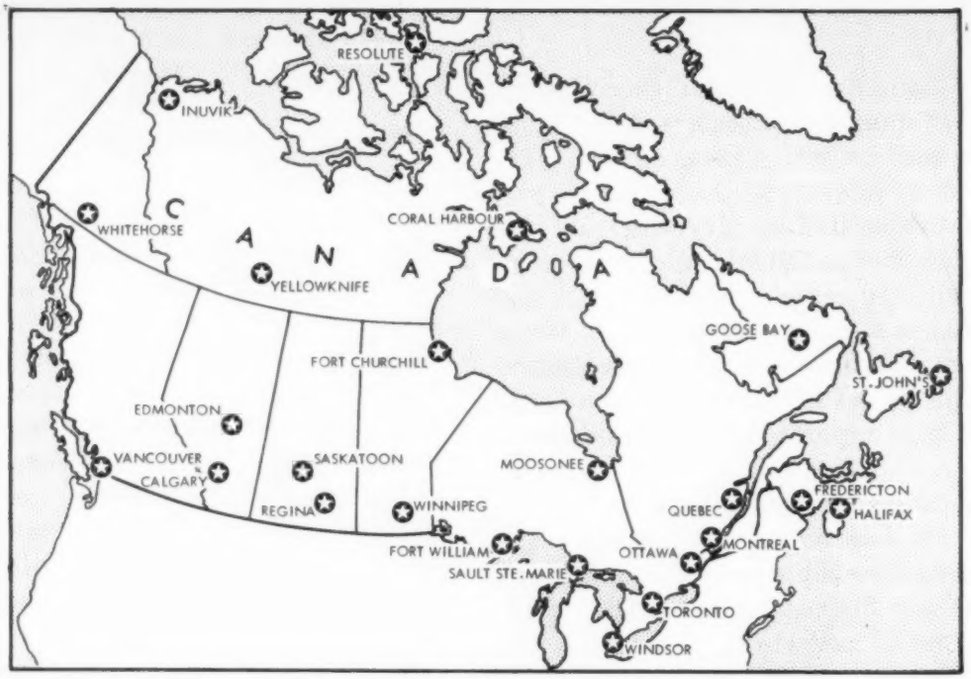

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for May 1964 samples are given in table 3. Radionuclide analyses appear quarterly.

TABLE 3.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, MAY 1964

Station	Air surveillance				Precipitation data	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	4.5	0.1	2.1	1,139	71.1
Coral Harbour	31	2.3	0.6	1.3		7.8
Edmonton	30	4.3	0.5	1.8	2,323	126.2
Ft. Churchill	29	3.7	0.1	1.2	2,192	36.7
Ft. William	31	3.3	0.3	1.7	1,190	167.1
Fredericton	31	3.6	0.1	1.5	798	39.9
Goose Bay	30	3.2	0.1	1.2	561	53.1
Halifax	25	4.0	0.1	1.9	749	44.7
Inuvik	31	2.6	0.1	1.3	730	5.6
Montreal	31	4.1	0.1	2.3	1,442	61.8
Moosonee	30	3.9	0.1	1.5	1,258	119.0
Ottawa	31	4.1	0.1	2.1	1,215	65.7
Quebec	31	4.0	0.1	1.8	827	66.9
Regina	31	7.0	0.4	2.3	1,322	47.3
Resolute	31	2.9	0.3	1.5	176	31.7
St. John's, Nfld	31	2.5	0.1	1.0	855	57.1
Saskatoon	30	4.9	0.5	2.4	1,455	63.1
Sault Ste. Marie	30	4.6	0.3	2.1	1,578	64.5
Toronto	31	4.1	0.1	2.2	1,565	66.7
Vancouver	31	2.6	0.4	1.5	2,055	90.7
Whitehorse	31	3.2	0.2	1.5	1,231	23.1
Windsor	31	3.7	0.2	2.2	874	38.1
Winnipeg	31	5.4	0.2	2.1	1,938	65.9
Yellowknife	31	2.4	0.3	1.2	2,098	24.5
Network summary		3.8	0.2	1.7	1,286	59.9

3. Mexican Air Monitoring Program May 1964

National Commission of Nuclear Energy

As part of its Radiological Protection Program, (RPP) the *Comision Nacional de Energía Nuclear* (CNEN) Mexico City, established the Radiation Surveillance Network of Mexico to provide a means for determining increased levels of radioactivity in air and precipitation.

The network has been gradually expanded to 17 stations (see figure 4). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada; staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during May 1964 are presented in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN SURFACE AIR, MEXICO, MAY 1964

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco	20	4.6	0.7	1.4
Ciudad Juárez	21	3.1	0.3	1.2
Chihuahua	19	4.5	0.4	1.7
Ensenada	12	2.4	1.0	1.9
Guadalajara	16	1.7	0.3	1.1
Guaymas	4	2.7	1.2	[a]
La Paz	18	4.7	1.2	2.7
Matamoros	7	0.8	0.2	0.5
Mazatlán	23	6.7	1.6	3.3
Mérida	7	1.2	0.4	0.9
México, D.F.	23	1.8	0.2	0.6
Nuevo Laredo	10	1.8	0.4	0.9
San Luis Potosí	7	1.2	0.3	0.6
Tampico	13	1.9	0.2	1.0
Torreón	25	2.8	0.3	1.3
Tuxtla Gutiérrez [b]				
Veracruz	20	3.5	0.3	1.1

[a] Average not calculated.
[b] Temporarily shut down.

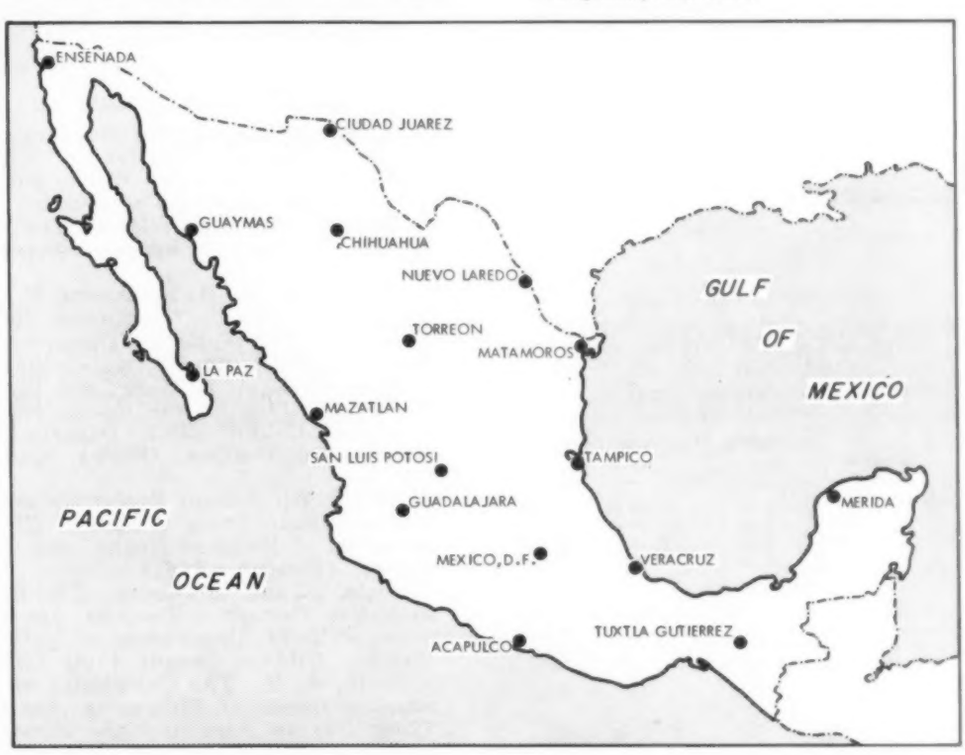

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

4. Pan American Air Sampling Program May 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964; the other three were started near the end of 1962.

The May 1964 air monitoring results from the four participating countries are given in table 5. The Caracas and Jamaica stations, included in figure 5 with the May averages adjusted by the RSN intercalibration factor,[3] were used in positioning the beta concentration isograms.

TABLE 5.—GROSS BETA ACTIVITY IN AIR, MAY 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	27	1.26	0.42	0.86
Caracas, Venezuela	21	1.08	<0.10	0.66
Lima, Peru	18	0.12	<0.10	<0.10
Santiago, Chile	22	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

[3] The RSN factor is 1.28.

5. Gross Beta Activity in Air, North America May 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian air network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican air monitoring program, new intercalibration ratios were determined, this time including the Canadian network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian air network, effective September 1963.

Figure 5 shows the May 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican air monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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(*1*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D. C. 20201 (Distribution by official request).

(*2*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review, 73:* 1318–30 (June 1, 1948).

(*3*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(*6*) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD–11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) *Booth, A. H.: The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

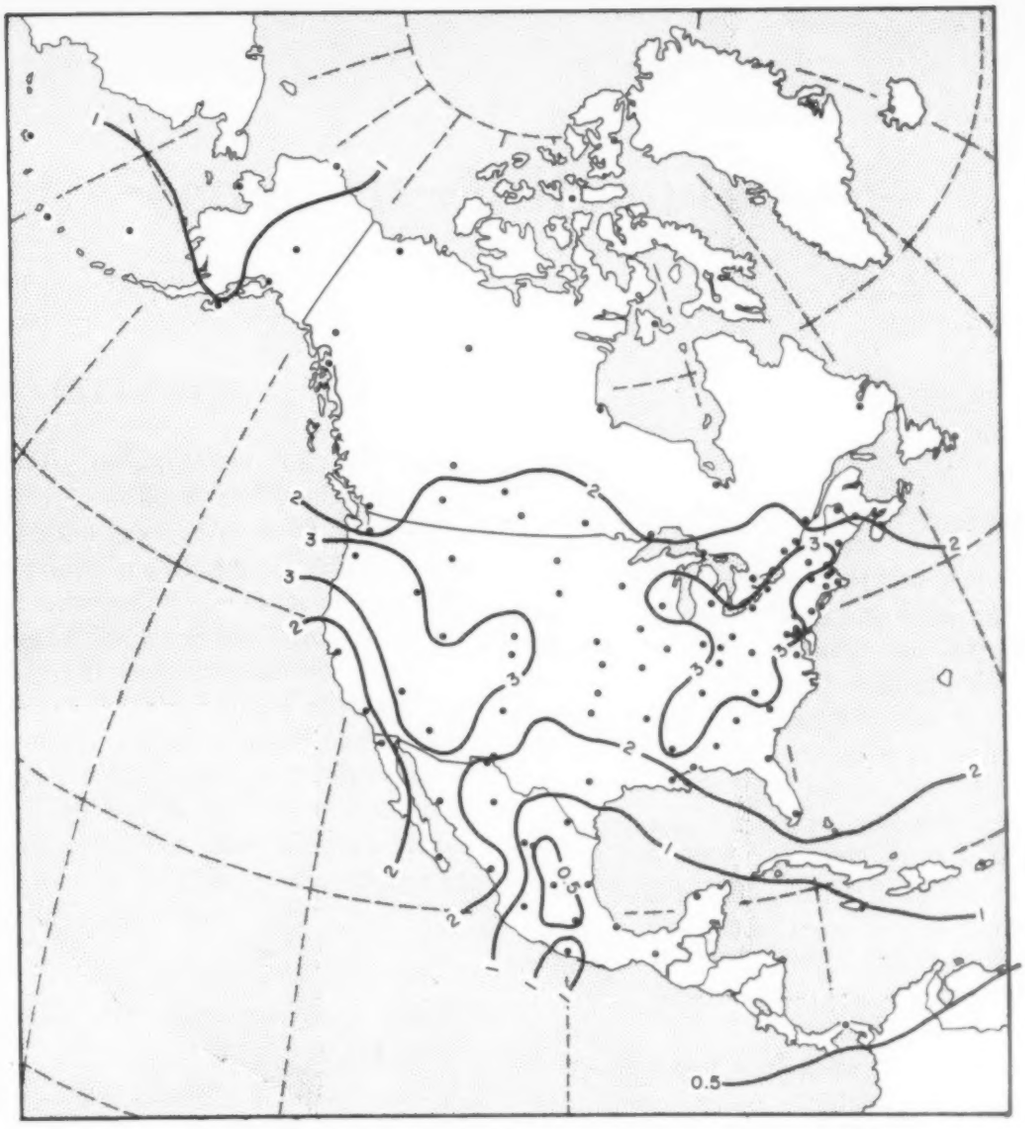

FIGURE 5.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, MAY 1964

(8) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850,* Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data,* December 1962.

(9) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025,* Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in *Radiological Health Data,* Jan. 1964.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, May 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma

scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclide and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The ± 2 standard deviations (2σ) about the measured concentration correspond to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for May 1964 (April 26-May 30, 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963, when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications of the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium–90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960-March 1964 in the July 1964 issue of *RHD* (*2*).

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MAY 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Ala:	Montgomery	1.19	1.15	1.5	1.5	<5	<5	24	30	100	100	June
Alaska:	Palmer	1.16	1.23	1.5	1.4	10	5	23	28	160	155	July
Ariz:	Phoenix	1.18	1.17	1.5	1.5	<5	<5	4	5	25	30	Sept
Ark:	Little Rock	1.18	1.14	1.5	1.5	<5	<5	43	69	165	190	July
Calif:	Sacramento	1.25	1.25	1.6	1.5	<5	<5	11	8	65	40	Aug
	San Francisco	1.23	1.21	1.5	1.5	<5	<5	13	11	75	50	June
Canal Zone:	Cristobal	1.13	1.10	1.6	1.6	<5	<5	6	6	50	55	July
Colo:	Denver	1.23	1.19	1.6	1.4	<5	<5	19	20	90	80	Aug
Conn:	Hartford	1.15	1.17	1.6	1.5	<5	<5	23	23	185	155	Aug
Del:	Wilmington	1.21	1.21	1.6	1.5	<5	<5	21	34	150	155	Sept
D. C:	Washington	1.17	1.09	1.6	1.5	<5	<5	18	25	105	100	June
Fla:	Tampa	1.21	1.13	1.5	1.5	<5	<5	15	15	200	275	Sept
Ga:	Atlanta	1.21	1.13	1.6	1.5	<5	<5	35	41	160	190	June
Hawaii:	Honolulu	1.18	1.15	1.6	1.6	<5	<5	11	10	80	85	July
Idaho:	Idaho Falls	1.19	1.20	1.6	1.5	5	10	27	30	220	195	Sept
Ill:	Chicago	1.18	1.12	1.6	1.5	<5	<5	21	17	145	130	June
Ind:	Indianapolis	1.22	1.21	1.6	1.5	<5	<5	22	30	120	105	Aug
Iowa:	Des Moines	1.22	1.20	1.5	1.5	<5	5	27	34	110	100	Sept
Kans:	Wichita	1.21	1.21	1.5	1.5	10	5	23	28	80	80	July
Ky:	Louisville	1.18	1.11	1.6	1.5	<5	<5	32	37	125	90	Sept
La:	New Orleans	1.22	1.18	1.5	1.5	<5	<5	54	59	165	195	July
Maine:	Portland	1.20	1.19	1.6	1.5	<5	<5	31	34	220	225	Sept
Md:	Baltimore	1.17	1.12	1.5	1.5	<5	<5	20	30	115	130	Sept
Mass:	Boston	1.20	1.19	1.6	1.6	<5	<5	32	39	265	240	June
Mich:	Detroit	1.19	1.16	1.6	1.5	<5	<5	19	22	135	130	Aug
	Grand Rapids	1.21	1.23	1.5	1.5	<5	<5	22	24	145	140	Sept
Minn:	Minneapolis	1.18	1.22	1.6	1.5	10	10	35	39	190	165	June
Miss:	Jackson	1.26	1.23	1.5	1.5	5	<5	41	54	125	130	Aug
Mo:	Kansas City	1.22	1.19	1.5	1.4	5	10	28	35	100	95	Aug
	St. Louis	1.20	1.19	1.5	1.5	5	<5	23	30	100	90	July
Mont:	Helena	1.22	1.18	1.5	1.6	10	<5	31	34	235	205	July
Nebr:	Omaha	1.21	1.28	1.5	1.5	5	5	25	32	105	105	Sept
Nev:	Las Vegas	1.24	1.19	1.6	1.5	<5	<5	15	13	95	85	June
N. H:	Manchester	1.22	1.18	1.7	1.5	<5	<5	32	34	260	250	Sept
N. J:	Trenton	1.19	1.17	1.6	1.5	5	<5	18	25	140	140	Aug
N. Mex:	Albuquerque	1.19	1.18	1.5	1.5	<5	<5	12	12	60	55	July
N. Y:	Buffalo	1.16	1.17	1.6	1.5	<5	<5	20	23	170	155	Aug
	New York	1.16	1.14	1.6	1.5	<5	<5	25	28	190	175	June
	Syracuse	1.18	1.16	1.6	1.6	<5	<5	22	24	170	165	July
N. C:	Charlotte	1.22	1.17	1.5	1.5	<5	<5	31	46	115	155	July
N. Dak:	Minot	1.21	1.18	1.5	1.5	15	20	58	77	160	175	Sept
Ohio:	Cincinnati	1.21	1.19	1.6	1.5	<5	<5	24	30	125	95	Aug
	Cleveland	1.21	1.18	1.6	1.5	<5	<5	22	24	135	125	July
Okla:	Oklahoma City	1.18	1.13	1.6	1.6	<5	<5	25	29	90	75	June
Ore:	Portland	1.24	1.26	1.5	1.4	5	10	27	43	155	160	Aug
Pa:	Philadelphia	1.21	1.17	1.6	1.6	<5	<5	20	28	145	150	July
	Pittsburgh	1.19	1.19	1.6	1.5	<5	<5	28	34	170	175	July
P. R:	San Juan	1.16	1.09	1.6	1.5	<5	<5	12	14	70	90	July
R. I:	Providence	1.18	1.18	1.6	1.5	<5	<5	25	27	185	175	Sept
S. C:	Charleston	1.18	1.14	1.5	1.5	<5	<5	34	35	135	180	Aug
S. Dak:	Rapid City	1.19	1.24	1.5	1.5	10	10	38	52	175	155	June
Tenn:	Chattanooga	1.23	1.14	1.5	1.5	5	<5	28	52	145	145	June
	Memphis	1.21	1.14	1.5	1.5	<5	<5	32	43	90	100	Sept
Tex:	Austin	1.17	1.13	1.6	1.5	<5	<5	10	10	45	50	June
	Dallas	1.19	1.13	1.6	1.6	<5	<5	22	24	85	70	Aug
Utah:	Salt Lake City	1.21	1.26	1.5	1.6	5	20	27	39	215	185	July
Vt:	Burlington	1.18	1.17	1.6	1.5	<5	<5	26	30	210	195	Aug
Va:	Norfolk	1.18	1.11	1.6	1.5	<5	<5	20	31	105	125	Aug
Wash:	Seattle	1.21	1.22	1.5	1.5	10	10	21	44	120	170	June
	Spokane	1.24	1.24	1.6	1.5	5	15	33	29	145	155	Aug
W. Va:	Charleston	1.18	1.13	1.5	1.5	<5	<5	26	40	110	95	June
Wis:	Milwaukee	1.22	1.23	1.7	1.6	<5	<5	19	20	160	145	Sept
Wyo:	Laramie	1.18	1.22	1.5	1.4	10	<5	21	25	115	110	Sept
Network average		1.20	1.18	1.6	1.5	<5	<5	24.8	30.3	136	135	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

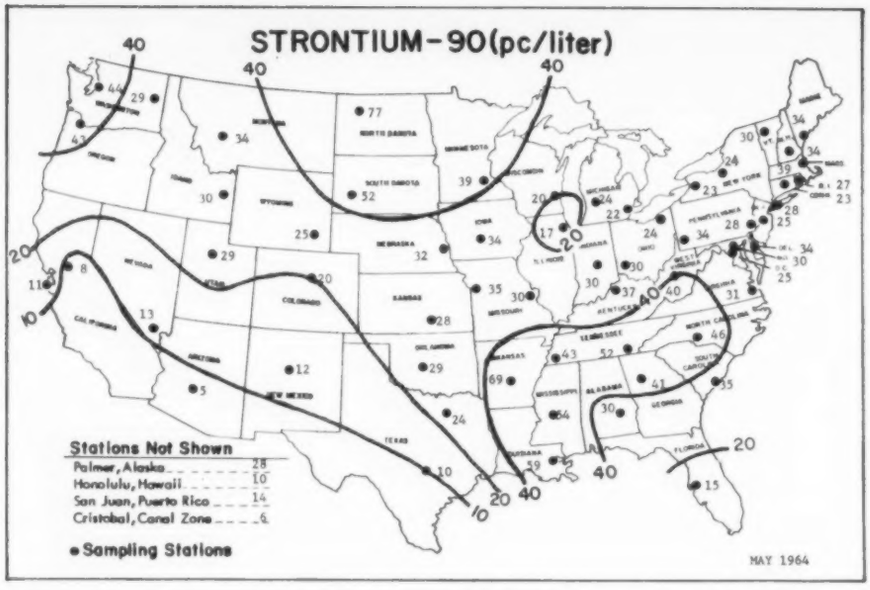

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, MAY 1964

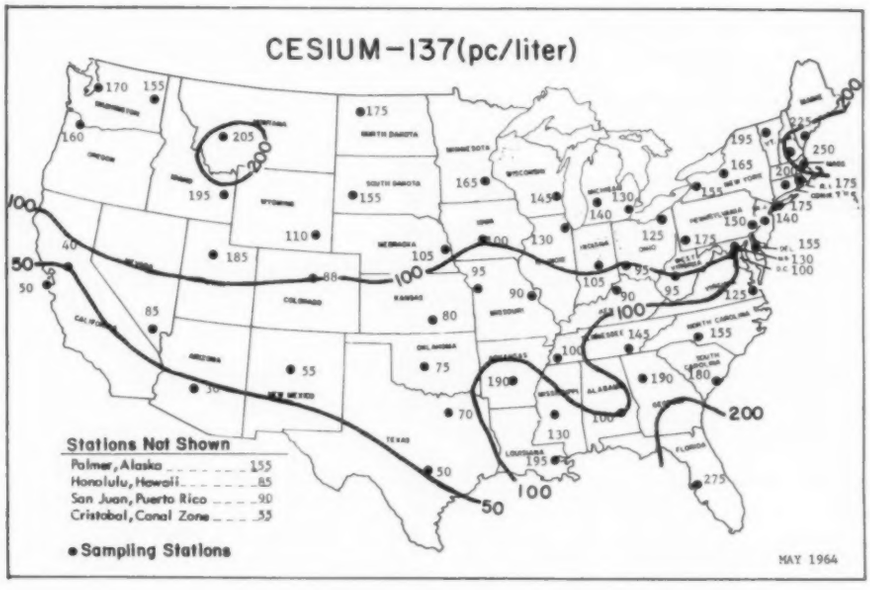

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, MAY 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, MAY 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations
<5	50	<1-9	3	<10	63	<5-45	2	<10	63
5	4	10-19	8			50-95	16		
10	6	20-29	20			100-145	17		
15	1	30-39	20			150-195	23		
20	2	40-49	6			200-245	3		
		50-59	4			250-295	2		
		60-69	1						
		70-79	1						

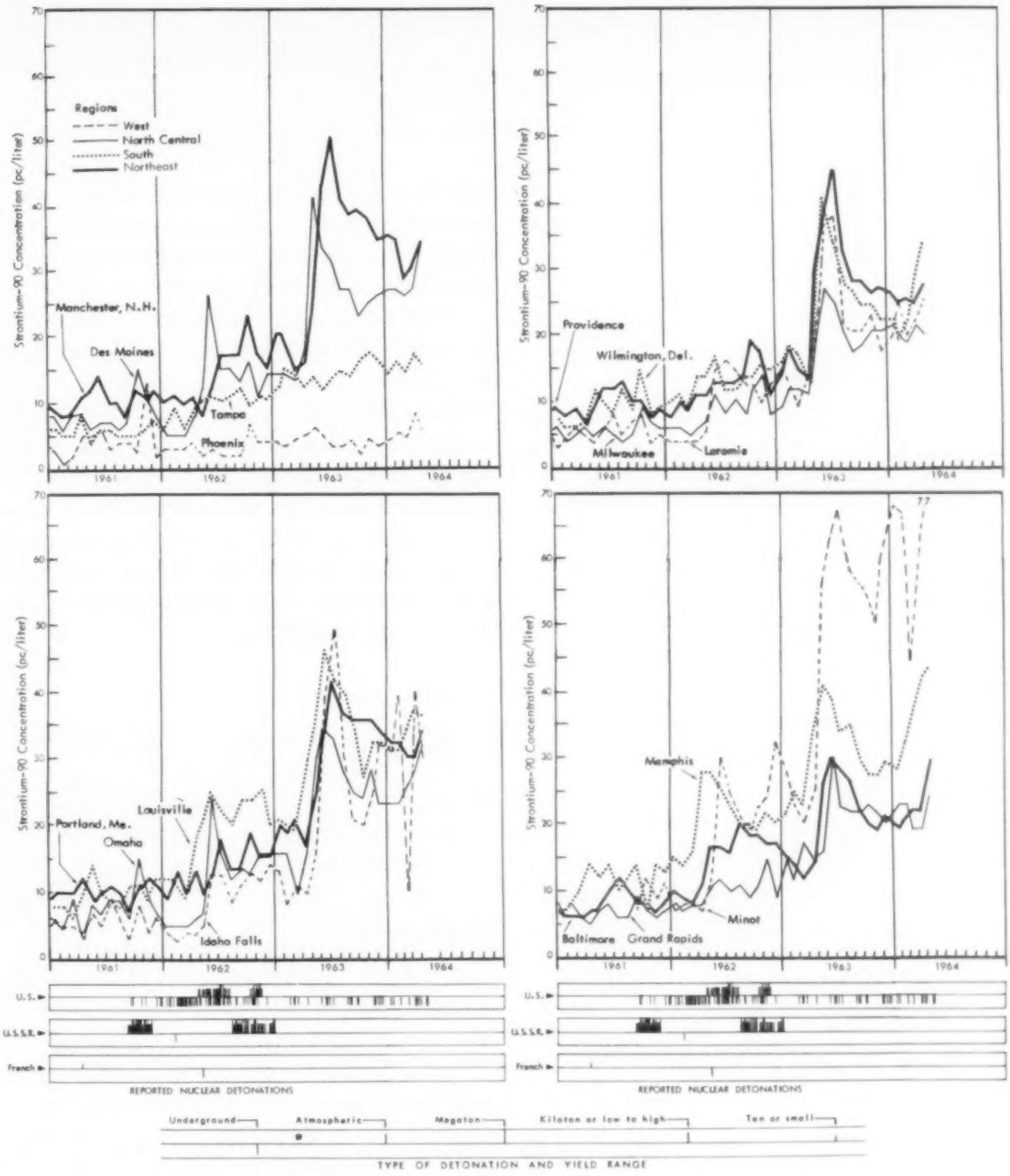

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961—MAY 1964

2. California Milk Network[3] January-March 1964

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly or biweekly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by

[3] Data from *Radiological Health News Vol. 3*, No. 3, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

FIGURE 4.—CALIFORNIA MILKSHEDS

the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

Analytical Procedures

After precipitation of the proteins with trichloroacetic acid, yttrium–90 is separated and beta counted, and total radiostrontium remaining in the filtrate is determined by beta counting in a low background counter, usually for a 60-minute period. Strontium–90 is determined from the yttrium–90 results; strontium–89 is determined by difference.

Potassium–40, iodine–131, cesium–137 and barium–140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium-iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium–40 concentration (pc/liter) by 1.18×10^{-3}. A more complete description of the laboratory equipment and procedures has been published in the February 1963 issue of *RHD* (*3*).

Results

The monthly averages of the radionuclide and calcium data for milk for the period January-March 1964 are presented in table 4. Background information on the differences among the California milksheds was presented by Heslep and Cornish in the December 1963 issue of *RHD* (*4*).

TABLE 4.—RADIONUCLIDES IN CALIFORNIA MILK,[a] JANUARY–MARCH 1964

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
January	1.33	1.21	1.15	1.16	1.19	1.22	1.18	1.20	1.18	1.21	1.21
February	1.29	1.26	1.22	1.12	1.21	1.24	1.13	1.18	1.34	1.26	1.22
March	1.21	1.25	1.19	1.03	1.24	1.26	1.19	1.19	1.32	1.25	1.21
Potassium-40											
January	1200	1180	1180	1280	1340	1220	1370	1200	1290	1340	1260
February	1100	1200	1160	1230	1290	1230	1240	1280	1240	1240	1220
March	1150	1290	1140	1260	1280	1250	1250	1250	1180	1270	1230
Strontium-89											
January	37	2	15	4	4	2	3	2	7	2	8
February	52	[b] 0	16	[b] 0	3	4	[b] 0	2	3	2	8
March	21	[b] 0	9	1	4	1	[b] 0	[b] 0	5	2	4
Strontium-90											
January	113	5.7	24.5	5.9	7.0	7.0	4.8	8.4	11.3	9.9	19.8
February	67	8.1	19.0	6.1	8.7	7.8	7.5	4.8	13.0	13.2	15.6
March	96	7.3	31.1	6.7	11.4	10.0	6.0	5.9	15.0	16.4	20.6
Cesium-137											
January	190	52	76	54	34	47	25	52	84	60	67
February	201	43	66	44	34	52	26	41	60	54	62
March	195	36	78	47	42	56	31	40	92	54	67

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
[b] Value given is not at least twice the counting error at the 95 percent confidence level.

3. Connecticut Milk Network
January-December 1963

Connecticut State
Department of Health

The Connecticut State Department of Health began monitoring pasteurized fluid milk for strontium–89 and strontium–90 in April 1960. Beginning in May 1962 the Department's milk monitoring program was expanded to include the determination of gamma emitters in milk samples.

The sampling program is flexible, and as many as five areas of the State have been sampled. The frequency of sample collection has been as often as twice a week. Presently, a monthly sample representative of milk sold in the central area of the State is collected from a processing plant in Hartford. These samples are analyzed for iodine–131, strontium–89 and strontium–90.

A low-background Geiger-Mueller counter with a thin end-window and gas-flow chamber is used for counting radiostrontium following chemical separation. Iodine–131 is determined by gamma scintillation spectroscopy using a 4″ x 4″ sodium iodide crystal and a 400-channel analyzer.

Table 5 gives the monthly average concentration of strontium–89, strontium–90, and iodine–131 in milk from Hartford, Connecticut during 1963. Radiostrontium data for 1963 are shown in figure 5. Connecticut milk monitoring data are not published on a regular monthly or quarterly basis in *RHD*. The previously published data for the period April 1960 through December 1962, appeared in the May 1963 issue (*5*).

TABLE 5.—RADIONUCLIDES IN HARTFORD, CONNECTICUT MILK, JANUARY-DECEMBER 1963

[Average concentrations in pc/liter]

Month 1963	Strontium-89	Strontium-90	Iodine-131
January	1	8.9	<10
February	2	8.9	<10
March	<1	11.0	<10
April	1	8.8	<10
May	27	12.6	<10
June	48	20.1	<10
July	67	30.0	<10
August	47	28.9	<10
September	13	26.6	<10
October	15	17.9	<10
November	8	21.3	<10
December	<1	22.9	<10

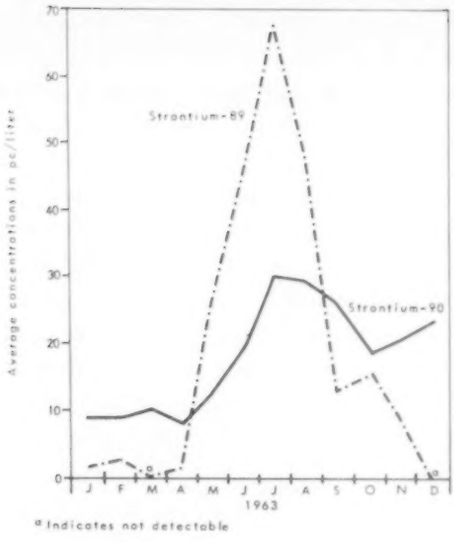

FIGURE 5.—RADIOSTRONTIUM IN HARTFORD, CONNECTICUT, MILK

4. Indiana Milk Network
May 1964

Bureau of Environmental Sanitation,
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 6).

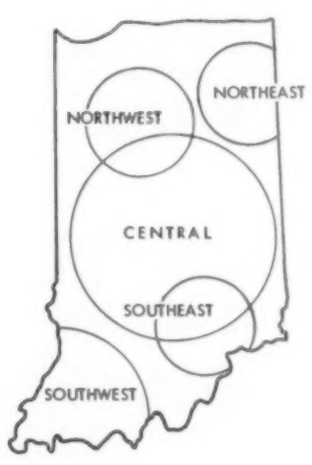

FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*6*) is employed for strontium–89 and strontium–90 analyses. Minimum detectable levels for strontium–89 and strontium–90 are about 5 and 1 pc/liter, respectively. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137 and barium–140. Analyses of counting statistics indicate that the lower limit of detectability for both iodine–131 and barium–140 is 5 pc/liter. Cesium–137 analyses are subject to a 6 percent error at the 100 pc/liter level. Additional factors such as drift of the analyzer and calibration factors will increase these limits to some extent.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 6.

TABLE 6.—RADIONUCLIDES IN INDIANA MILK, MAY 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	Potassium-40	Strontium-90	Cesium-137
Northeast	1.16	1,300	22	105
Southeast	1.13	1,480	26	90
Central	1.22	1,450	30	95
Southwest	1.19	1,340	26	100
Northwest	1.15	1,440	28	115
State average	1.17	1,400	26	100

[a] The monthly average iodine-131, barium-140, and strontium-89 concentrations at each station were zero.

5. New York Milk Network March 1964

Division of Environmental Health Services
State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 7) are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium–lanthanum–140 at all stations except Massena, where samples are composited bi-weekly, and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

FIGURE 7.—NEW YORK MILK SAMPLING LOCATIONS

A matrix method (*7*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of in-growth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 7.

TABLE 7.—RADIONUCLIDES IN NEW YORK MILK, MARCH 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	<3	20	126
Buffalo	<3	16	105
Massena	10	27	226
Newburgh	6	19	126
New York City	3	25	142
Syracuse	4	18	122
Average	5	21	141

[a] The monthly average I^{131} and $Ba\text{-}La^{140}$ (in equilibrium) at each station was <20 pc/liter.

6. Canadian Milk Network [4]
May 1964

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 8) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137 and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In

[4] Data from *Radiation Protection Programs, Vol. 2, No. 6:* 25–29, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (June 1964).

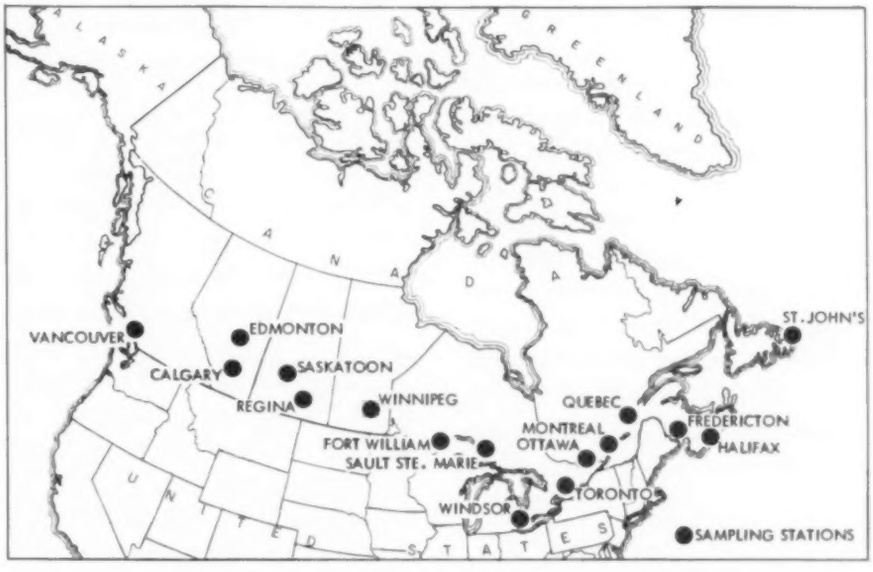

FIGURE 8.—CANADIAN MILK SAMPLING STATIONS

most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method, the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

TABLE 8.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 9 presents monthly averages of strontium–90, cesium–137 and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had <5 pc/liter.

TABLE 9.—RADIONUCLIDES IN CANADIAN WHOLE MILK, MAY 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.38	1.4	53.7	271
Edmonton	1.41	1.5	41.9	235
Ft. William	1.34	1.5	67.4	309
Fredericton	1.42	1.5	52.9	341
Halifax	1.48	1.6	42.1	254
Montreal	1.39	1.6	41.1	255
Ottawa	1.42	1.7	32.7	207
Quebec	1.38	1.6	47.7	302
Regina	1.35	1.6	57.6	175
St. John's, Nfld	1.39	1.6	40.8	268
Saskatoon	1.39	1.6	61.2	181
Sault Ste. Marie	1.42	1.6	46.1	215
Toronto	1.40	1.6	19.5	141
Vancouver	1.46	1.6	63.3	442
Windsor	1.46	1.6	19.4	98
Winnipeg	1.33	1.6	49.3	224
Average	1.40	1.6	46.4	245

Note: Strontium-89 and iodine-131 levels not reported because of insignificantly low levels (5 pc/liter or less).

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MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1963—MAY 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and to one-third of the RPG for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

[1] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		May 1963 [b] April 1964	June 1963 [c] May 1964	May 1963 [b] April 1964	June 1963 [c] May 1964	May 1963 [b] April 1964	June 1963 [c] May 1964
Ala:	Montgomery	31	21	23	23	91	91
Alaska:	Palmer	27	25	24	25	149	157
Ariz:	Phoenix	6	4	4	4	24	25
Ark:	Little Rock	64	47	45	47	168	167
Calif:	Sacramento	21	12	11	9	65	60
	San Francisco	31	16	13	12	75	69
Colo:	Denver	22	20	19	20	93	95
Conn:	Hartford	21	18	26	27	183	184
Del:	Wilmington	25	20	27	27	148	150
D. C:	Washington	33	24	20	20	106	106
Fla:	Tampa	15	12	15	15	235	241
Ga:	Atlanta	49	34	33	33	161	161
Hawaii:	Honolulu	16	10	11	11	82	83
Idaho:	Idaho Falls	47	43	30	31	178	187
Ill:	Chicago	18	16	21	21	125	130
Ind:	Indianapolis	24	18	24	24	112	112
Iowa:	Des Moines	51	35	28	28	102	101
Kans:	Wichita	35	30	22	23	80	81
Ky:	Louisville	65	50	35	36	125	122
La:	New Orleans	51	38	47	49	162	163
Maine:	Portland	26	24	34	34	228	235
Md:	Baltimore	42	33	23	23	133	133
Mass:	Boston	31	28	37	38	261	270
Mich:	Detroit	15	14	21	21	124	128
	Grand Rapids	16	15	22	23	132	137
Minn:	Minneapolis	47	44	34	35	166	171
Miss:	Jackson	53	36	39	40	121	120
Mo:	Kansas City	56	43	31	30	96	95
	St. Louis	41	31	25	26	96	98
Mont:	Helena	43	37	31	32	207	214
Nebr:	Omaha	44	34	28	28	107	109
Nev:	Las Vegas	14	12	11	11	81	84
N. H:	Manchester	28	25	36	37	280	288
N. J:	Trenton	21	17	22	22	138	141
N. Mex:	Albuquerque	16	13	12	12	54	56
N. Y:	Buffalo	21	18	24	24	156	161
	New York	29	27	31	32	188	194
	Syracuse	24	21	25	26	156	163
N. C:	Charlotte	50	39	34	35	131	134
N. Dak:	Minot	80	66	58	60	157	163
Ohio:	Cincinnati	27	21	28	27	105	105
	Cleveland	22	19	23	23	123	127
Okla:	Oklahoma City	41	28	24	24	93	89
Ore:	Portland	50	34	33	32	177	175
Pa:	Philadelphia	24	18	24	24	140	142
	Pittsburgh	31	27	31	32	168	174
P. R:	San Juan	25	17	13	13	88	85
R. I:	Providence	23	20	29	29	186	190
S. C:	Charleston	32	21	29	30	136	142
S. Dak:	Rapid City	59	52	43	45	170	174
Tenn:	Chattanooga	68	49	42	42	158	156
	Memphis	51	36	33	34	95	94
Tex:	Austin	14	11	9	10	48	49
	Dallas	32	21	21	21	84	81
Utah:	Salt Lake City	30	29	27	28	186	193
Vt:	Burlington	25	23	30	31	203	210
Va:	Norfolk	31	23	23	23	109	109
Wash:	Seattle	45	31	27	28	161	159
	Spokane	45	34	31	31	154	154
W. Va:	Charleston	55	40	31	31	110	108
Wis:	Milwaukee	16	15	21	21	136	142
Wyo:	Laramie	35	29	24	24	120	120
Network average		34	27	26.6	27	136	138

[a] All iodine-131 annual averages were <10 pc/liter. [b] Averages compiled on a 52-week basis. [c] Averages compiled on a 53-week basis.

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STRONTIUM-90 IN TRI-CITY DIETS, NOVEMBER 1963–JANUARY 1964[1]

Health and Safety Laboratory, AEC

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium–90. Using data from the U. S. Department of Agriculture (*1*) the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium–90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data (*1*) are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results obtained from the November 1963-January 1964 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Discussion

The previously noted geographic pattern of distribution of strontium–90 in the diet is seen to persist in the last sampling: levels have been highest in New York City and lowest in San Francisco. Partly due to its high annual consumption, milk continues to be the predominant source of strontium–90 in the diet.

[1] Summarized from *Fallout Program Quarterly Summary Report, HASL–146*:183–5, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964), price $3.50.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE

Food category	Average U.S. consumption		New York City November 1963		Chicago January 1964		San Francisco December 1963	
	Diet (kg/yr)	Calcium (g/yr)	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr
Bakery products	37	37.0	32.8±1.30	1,212	28.54±1.70	1,056	23.4±1.45	866
Whole grain products	11	10.0	83.3±1.36	916	80.7 ±2.62	888	25.0±1.40	275
Eggs	16	9.1	4.2±0.09	67	8.6 ±0.29	138	5.0±0.28	80
Fresh vegetables	43	15.0	29.6±0.62	1,274	18.2 ±0.63	783	5.4±0.41	232
Root vegetables	17	6.1	7.8±0.39	133	9.0 ±0.40	153	10.9±0.58	186
Milk	221	234.3	27.7±0.71	6,115	18.0 ±0.62	3,978	11.8±0.50	2,610
Poultry	17	9.2	2.3±0.07	38	3.7 ±0.01	62	2.1±0.08	36
Fresh fish	8	10.8	2.0±0.15	16	1.3 ±0.14	10	0.8±0.14	7
Flour	43	8.6	34.8±0.71	1,497	28.7 ±0.58	1,232	17.7±0.47	762
Macaroni	3	0.7	14.3±0.13	43	21.9 ±0.43	66	11.6±0.53	35
Rice	3	1.1	7.7±0.24	23	4.4 ±0.28	13	2.0±0.36	6
Meat	73	10.9	0.8±0.09	55	1.2 ±0.07	88	2.0±0.08	149
Shellfish	1	0.8	4.4±0.23	4	1.4 ±0.25	1	12.2±0.36	12
Dried beans	3	2.9	38.2±1.94	115	37.8 ±2.22	114	10.6±1.47	32
Fresh fruit	68	13.6	7.0±0.33	475	4.8 ±0.22	328	1.9±0.20	133
Potatoes	45	5.8	6.5±0.44	287	7.6 ±0.68	341	2.6±0.36	115
Canned fruit	26	1.3	2.3±0.14	59	2.4 ±0.17	61	1.7±0.13	45
Fruit juices	19	1.7	6.7±0.35	127	7.6 ±0.49	145	3.2±0.32	61
Canned vegetables	20	4.2	14.6±0.58	291	9.1 ±0.65	181	2.5±0.41	49
Annual intake	674	383		12,747		9,638		5,691
pc Sr^{90}/g Ca in total diet				33.3		25.2		14.9

[a] Error terms are one standard deviation (due to counting).

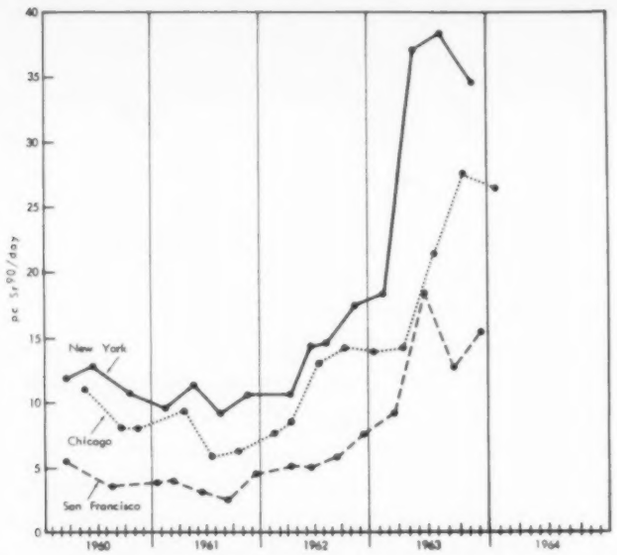

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

In New York City and Chicago the strontium–90 intakes were about the same as those found three months earlier. There was a slight increase in the strontium–90 intake estimated for San Francisco. The average Sr–90/Ca ratio in the diets at the three cities during 1963 were 30, 19, and 14 pc/g Ca for New York City, Chicago, and San Francisco, respectively.

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Recent coverage in *Radiological Health Data:*

Period	Issue
Thirteenth sampling (May-July 1963)	*March 1964*
Fourteenth sampling (August-October 1963)	*June 1964*

CESIUM-137 IN TRI-CITY DIETS, OCTOBER–DECEMBER 1962[1]

Joseph Rivera and John J. Kelly[2]

Since March 1960, the Health and Safety Laboratory diet study has made estimates of the strontium–90 content of the average diets of individuals living in New York City, San Francisco, and Chicago (see preceding article, p. 433). Occasionally, some samples from this study are analyzed for cesium–137.

Anderson *et al.* (*1*) showed that cesium–137 levels in fallout, milk, and people could be related, but a number of assumptions as to the magnitude of the contamination of nonmilk fractions of the diet, and the time lag between production and consumption of these foods had to be made before good agreement between observation and theory could be obtained. In an attempt to verify these assumptions and to obtain more data to base predictions of future body levels of cesium–137 in humans, a limited number of samples from the Tri-City Diet Study are being analyzed for cesium–137. The fourth quarter 1962 results of these analyses are presented in table 1. Fourth quarter 1963 results have previously been published (*2*). A comparison of both 1962 and 1963 results may be seen in figure 1.

Analytical Method

The radiochemical analysis of the food composites was accomplished using the procedure developed in this laboratory (*3*). This method has been briefly described elsewhere (*2*).

Experiments to establish the precision and accuracy of cesium–137 analyses are continuing. The reproducibility of six pairs of blind duplicates analyzed with the samples reported here was, as in the last report, better than ±10 percent.

[1] Data from *Fallout Program Quarterly Summary Report, HASL–146*:233–5, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (July 1, 1964), price $3.50.

[2] Mr. Rivera is a physicist and Mr. Kelly is a member of the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, N.Y.C. 10014.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND CESIUM-137 INTAKE OCTOBER–DECEMBER 1962

Food category	U.S. consumption kg/yr	New York City November 1962		Chicago October 1962		San Francisco December 1962	
		[a] pc/kg	pc/yr	[a] pc/kg	pc/yr	[a] pc/kg	pc/yr
White bread	37	11.9±2.0	440	53.3±2.7	1,972	39.9±2.1	1,476
Whole grain products	11	63.4±3.3	697	45.0±2.5	495	59.1±2.6	650
Eggs	16	6.2±0.4	99	13.8±0.3	221	0.5±0.8	8
Fresh vegetables	43	10.3±0.9	443	5.5±0.2	237	3.2±0.6	138
Root vegetables	17	14.9±0.8	253	4.8±0.8	82	3.9±0.5	66
Milk	221	59.7±1.5	13,194	37.4±1.3	8,265	17.1±0.9	3,779
Poultry	17	15.2±0.4	258	5.9±0.3	100	18.1±0.4	308
Fresh fish	8	9.6±0.4	77	63.2±1.6	506	20.8±0.5	166
Flour	43	40.5±1.0	1,742	45.7±1.1	1,965	23.6±0.8	1,015
Macaroni	3	56.9±1.3	171	39.3±1.5	118	53.2±1.9	160
Rice	3	36.0±1.5	108	18.9±1.1	57	16.0±0.7	48
Meat	73	35.1±0.6	2,562	57.5±0.9	4,198	42.1±0.8	3,073
Shellfish	1	10.4±0.6	10	8.0±0.3	8	3.8±0.2	4
Dried beans	3	11.9±2.3	36	24.8±3.0	74	59.8±4.7	179
Fresh fruit	68	20.9±0.9	1,421	11.4±1.1	748	4.1±0.5	279
Potatoes	45	16.2±1.0	729	8.9±0.6	401	7.8±0.9	351
Canned fruit	26	7.2±0.3	187	24.5±1.7	637	8.4±0.4	218
Fruit juices	19	11.7±0.5	222	14.0±0.9	266	8.7±0.5	165
Canned vegetables	20	10.2±1.0	204	31.4±1.5	628	4.1±0.8	82
Annual intake	674		22,853		20,978		12,165
Daily intake (pc/day)			63		57		33

[a] Error terms are one standard deviation (due to counting).

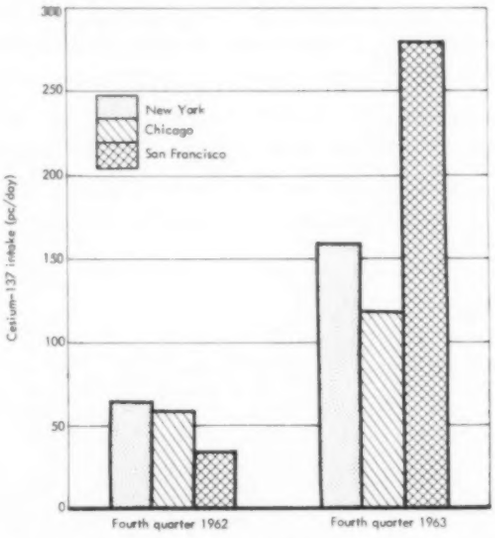

FIGURE 1.—DAILY INTAKE OF CESIUM–137, TRI-CITY DIETS

Some estimate of the accuracy of interlaboratory calibrations of standard solutions used in determining the efficiency of the counters for cesium–137 activity may be seen from table 2. From this table it is evident that calibration differences among laboratories of about 10 percent may exist.

As was discussed in the previous report, there is a possibility that the cesium–137 values may be low due to ashing at high temperatures (500–600°C.). To test this, a milk sample was divided into two parts; half was wet-ashed prior to radiochemical analysis and the other half was dry ashed before analysis. The entire liquid milk sample was also analyzed by gamma-ray spectroscopy for cesium–137 before ashing. The results of (1) gamma spectroscopy, (2) wet ashing, and (3) dry ashing in units of pc Cs^{137}/sample are 200 ±5, 172 ±2, and 176 ± 3, respectively.

TABLE 2.—INTERCOMPARISON OF CESIUM-137 STANDARDS BY 4π BETA COUNTING

Name of standard and analyzing laboratories	Results (disintegration/min./sample)
National Bureau of Standards standard	
National Bureau of Standards	[a] 3.38×10^{5}
Health and Safety Laboratory	2.93×10^{5}
Los Alamos Scientific Laboratory	3.22×10^{5}
Isotopes, Incorporated	3.08×10^{5}
Atomic Energy of Canada, Ltd, standard	
Atomic Energy of Canada, Ltd	1.49×10^{5}
Health and Safety Laboratory	1.48×10^{5}
Los Alamos Scientific Laboratory	1.46×10^{5}
Isotopes, Incorporated	1.48×10^{5}
Atomic Energy Research Establishment standard	
Atomic Energy Research Establishment	2.39×10^{5}
Health and Safety Laboratory	2.35×10^{5}
Nuclear Chicago standard	
Nuclear Chicago	[a] 7.20×10^{5}
Health and Safety Laboratory	6.61×10^{5}
International Atomic Energy Agency standard	
International Atomic Energy Agency	2.242×10^{7}
Health and Safety Laboratory	2.177×10^{7}

[a] Calculated from gamma activity measurements.

From this experiment it is concluded that no appreciable cesium–137 was lost due to the ashing temperature, but that gamma spectroscopy may yield a higher cesium–137 value than chemical analysis. Many more experiments of this type will of course have to be done to establish this with certainty.

Discussion

As was expected from the strontium–90 fallout levels, the concentrations of cesium–137 in foods purchased at the end of 1962 were very much less than at the end of 1963. The estimated daily intakes of cesium–137 from the 1962 and 1963 samplings were 63 and 156 pc/day in New York City, 57 and 116 pc/day in Chicago and 33 and 278 pc/day in San Francisco. With no other information available, it may be concluded that the best estimate of cesium–137 intake during 1963 would be the arithmetic average which was 110 pc/day in New York City, 90 pc/day in Chicago and 160 pc/day in San Francisco. From the data of Brar *et al.* (*4*), it may be concluded that the cesium–137 intake in Chicago during 1963 was about 160 pc/kg. For individual components Brar's results are usually higher than HASL's results by a factor somewhat less than two. Reasons for this discrepancy are under investigation.

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(*2*) U. S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–144*:288–90, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (April 1, 1964), price $4.00. Summarized in *Radiological Health Data, 5*:288–90, (June 1964).

(*3*) U. S. Atomic Energy Commission: *Manual of Standard Laboratory Procedures, NYO–4700,* Health and Safety Laboratory, AEC, 376 Hudson St., New York, N. Y. 10014, (Revised August 1962).

(*4*) Brar, S. S., P. Gustafson, and S. Muniak: *U. S.* "Cesium–137 in Various Chicago Foods", p. 225, *Atomic Energy Commission Report No. HASL–146,* (July 1, 1964).

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MARCH 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 130 stations as of July 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System and exact locations of sampling points are published in an annual compilation (*1–7*).

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, MARCH 1964

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Strontium–90 analyses are performed quarterly.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from most stations. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established System stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Results

Table 1 presents March 1964 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the March 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al.* (*9*). The most recent strontium–90 results appeared in the August 1964 issue of *RHD* (*10*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia and Clinch Rivers. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 143 and 610 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, range in monthly averages to 42 pc/liter. Of all stations, four on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface waters, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*12*).

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, MARCH 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	14	9	23	1	0	1
Animas River:						
Cedar Hill, N. Mex	70	18	88	13	3	16
Apalachicola River:						
Chattahoochee, Fla	5	20	25	0	0	0
Arkansas River:						
Coolidge, Kansas	48	54	102	5	30	35
Ponca City, Okla	4	18	22	0	1	1
Fort Smith, Ark	23	31	54	1	0	1
Little Rock, Ark	42	26	68	6	1	7
Pendleton Ferry, Ark	37	16	53	3	0	3
Bear River:						
Preston, Idaho	1	22	23	0	0	0
Big Horn River:						
Hardin, Mont	67	25	92	12	6	18
Big Sioux River:						
Sioux Falls, S. Dak	0	60	60	0	2	2
Chattahoochee River:						
Atlanta, Ga	1	3	4	0	0	0
Columbus, Ga	23	18	41	3	1	4
Lanett, Ala	23	10	33	1	0	1
Chena Slough:						
Fairbanks, Alaska	2	6	8	0	1	1
Clearwater River:						
Lewiston, Idaho	7	11	18	0	0	0
Clinch River:						
Clinton, Tenn	4	10	14	<1	<1	<1
Kingston, Tenn	19	226	245	0	1	1
Colorado River:						
Loma, Colo	22	28	50	4	8	12
Page, Ariz	1	40	41	0	9	9
Boulder City, Nev	1	23	24	0	5	5
Parker Dam, Calif-Ariz	2	18	20	0	5	5
Yuma, Ariz	6	77	83	1	8	9
Columbia River:						
Northport, Wash	7	7	14	1	1	2
Wenatchee, Wash	3	12	15	0	1	1
Pasco, Wash	69	610	679	0	1	1
McNary Dam, Ore	34	370	404	0	1	1
Bonneville, Ore	9	236	245	0	1	1
Clatskanie, Ore	28	143	171	0	<1	<1
Connecticut River:						
Wilder, Vt	10	16	26	0	0	0
Northfield, Mass	1	10	11	0	0	0
Enfield Dam, Conn	8	13	21	0	0	0
Cumberland River:						
Clarksville, Tenn	No Report					
Cuyahoga River:						
Cleveland, Ohio	17	25	42	1	0	1
Delaware River:						
Martins Creek, Pa	3	15	18	0	0	0
Trenton, N. J	6	10	16	0	0	0
Philadelphia, Pa	13	9	22	1	0	1
Escambia River:						
Century, Fla	9	11	20	0	0	0
Great Lakes:						
Duluth, Minn	0	3	3	0	0	0
Sault Ste. Marie, Mich	0	6	6	1	0	1
Milwaukee, Wisc	1	7	8	0	0	0
Gary, Ind	3	10	13	0	0	0
Port Huron, Mich	7	9	16	0	0	0
Detroit, Mich	2	9	11	0	1	1
Buffalo, New York	1	15	16	0	0	0
Green River:						
Dutch John, Utah	3	36	39	0	4	4
Hudson River:						
Poughkeepsie, N. Y	5	17	22	0	1	1
Illinois River:						
Peoria, Ill	15	19	34	1	0	1
Grafton, Ill	21	31	52	1	2	3
Kanawha River: Winfield Dam, W. Va	14	3	17	1	0	1
Kansas River:						
De Soto, Kansas	7	32	39	1	3	4
Klamath River:						
Keno, Oreg	6	18	24	0	0	0
Little Miami River:						
Cincinnati, Ohio	142	24	166	20	1	21
Maumee River:						
Toledo, Ohio	28	37	65	2	1	3
Merrimack River:						
Lowell, Mass	6	11	17	0	0	0
Mississippi River:						
St. Paul, Minn	4	16	20	0	1	1
Dubuque, Iowa	0	12	12	0	1	1
Burlington, Iowa	9	18	27	1	2	3
E. St. Louis, Ill	12	21	33	1	1	2
Cape Girardeau, Mo	39	24	63	7	1	8
W. Memphis, Ark	46	12	58	7	0	7
Vicksburg, Miss	44	18	62	5	0	5
Delta, La	54	15	69	14	0	14
New Orleans, La	29	14	43	7	0	7
Missouri River:						
Williston, N. Dak	6	21	27	0	5	5
Bismarck, N. Dak	3	30	33	0	2	2
Yankton, S. Dak	4	20	24	0	3	3
Omaha, Nebr	16	20	36	2	2	4
St. Joseph, Mo	18	20	38	2	4	6
Kansas City, Kans	20	21	41	2	5	7
Missouri City, Mo	8	21	29	1	3	4
St. Louis, Mo	24	23	47	2	5	7
Monongahela River:						
Pittsburgh, Pa	16	8	24	0	0	0
North Platte River:						
Henry, Nebr	4	35	39	0	30	30
Ohio River:						
Toronto, Ohio	4	8	12	1	0	1
Addison, Ohio	49	11	60	7	1	8
Huntington, W. Va	6	12	18	0	0	0
Cincinnati, Ohio	22	9	31	3	0	3
Louisville, Ky	12	9	21	1	0	1
Evansville, Ind	43	9	52	3	0	3
Cairo, Ill	50	13	63	4	1	5
Ouachita River:						
Bastrop, La	24	29	53	3	0	3
Pend Oreille River:						
Albeni Falls Dam, Idaho	4	6	10	0	1	1
Platte River:						
Plattsmouth, Nebr	66	30	96	8	8	16
Potomac River:						
Williamsport, Md	0	9	9	0	0	0
Great Falls, Md	12	13	25	1	0	1
Washington, D.C	5	7	12	0	0	0
Rainy River:						
Baudette, Minn	4	29	33	0	0	0
International Falls, Minn	2	24	26	0	0	0
Raritan River:						
Perth Amboy, N. J. (5 ft. Below Surface)	3	14	17	0	4	4
Perth Amboy, N. J. (5 ft. Above Bottom)	2	8	10	2	3	5
Red River, North:						
Grand Forks, N. Dak	3	44	47	0	0	0
Red River, South:						
Denison, Tex	2	58	60	0	0	0
Index, Ark	105	23	128	13	1	14
Bossier City, La	62	29	91	8	1	9
Alexandria, La	46	6	52	5	0	5
Rio Grande River:						
Alamosa, Colo	4	9	13	0	1	1
El Paso, Tex	91	25	116	5	2	7
Laredo, Tex	8	20	28	0	5	5
Brownsville, Tex	3	18	21	0	3	3
Roanoke River:						
John H. Kerr Resr/ Dam, Va	10	16	26	1	0	1
Sabine River:						
Ruliff, Tex	16	35	51	1	0	1
Sacramento River:						
Greens Landing, Calif	19	4	23	0	0	0
St. Lawrence River:						
Massena, N. Y	0	11	11	0	0	0
San Joaquin River:						
Vernalis, Calif	6	15	21	1	9	10
San Juan River:						
Shiprock, N. Mex	7	30	37	0	13	13
Savannah River:						
North Augusta, S. C	14	14	28	2	1	3
Port Wentworth, Ga	7	20	27	1	0	1
Schuylkill River:						
Philadelphia, Pa	3	5	8	0	0	0
Shenandoah River:						
Berryville, Va	18	6	24	2	0	2
Ship Creek:						
Anchorage, Alaska	0	2	2	0	0	0
Snake River:						
Ice Harbor Dam, Wash	3	12	15	0	2	2
Wawawai, Wash	5	13	18	1	2	3
Payette, Idaho	5	24	29	1	5	6
South Platte River:						
Julesburg, Colo	14	52	66	0	42	42
Spokane River:						
Post Falls Dam, Idaho	4	6	10	0	0	0
Susquehanna River:						
Sayre, Pa	5	9	14	0	0	0
Conowingo, Md	6	6	12	1	1	2
Tennessee River:						
Lenoir City, Tenn	8	9	17	0	1	1
Chattanooga, Tenn	15	20	35	1	0	1
Bridgeport, Ala	16	15	31	2	0	2
Pickwick Landing, Tenn	12	17	29	1	0	1
Tombigbee River:						
Columbus, Miss	45	22	67	5	0	5
Truckee River:						
Farad, Calif	2	7	9	0	0	0
Verdigris River:						
Nowata, Okla	10	43	53	2	6	8
Wabash River:						
New Harmony, Ind	79	17	96	10	1	11
Willamette River:						
Portland, Oreg	9	7	16	0	0	0
Yakima River:						
Richland, Wash	1	5	6	0	1	1
Yellowstone River:						
Sidney, Mont	9	18	27	0	4	4
Maximum	142	610	679	20	42	42
Minimum	0	2	2	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (7).

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(*2*) *Ibid.*, 1959 Edition. Price $1.75.
(*3*) *Ibid.*, 1960 Edition.[2]
(*4*) *Ibid.*, 1961 Edition.[2]
(*5*) *Ibid.*, 1962 Edition.[2]
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(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN CALIFORNIA SURFACE WATERS[1] JULY-DECEMBER 1963

Bureau of Radiological Health, State of California Department of Public Health

Results obtained by the Bureau of Radiological Health in its monitoring of California surface water during the period July to December 1963 are summarized below. The importance of this facet of the Bureau's environmental surveillance program stems from the fact that most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams, any radioactivity that may be added by the discharge of sewage or industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters, although a few wells, along with some water supplies that use infiltration galleries, are also sampled (figure 1).

It is necessary to monitor domestic water supplies on a continuing basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The Bureau has established a monthly sampling schedule whereby 500-ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of six months to make up a composite of approximately five gallons for strontium–90 analysis.

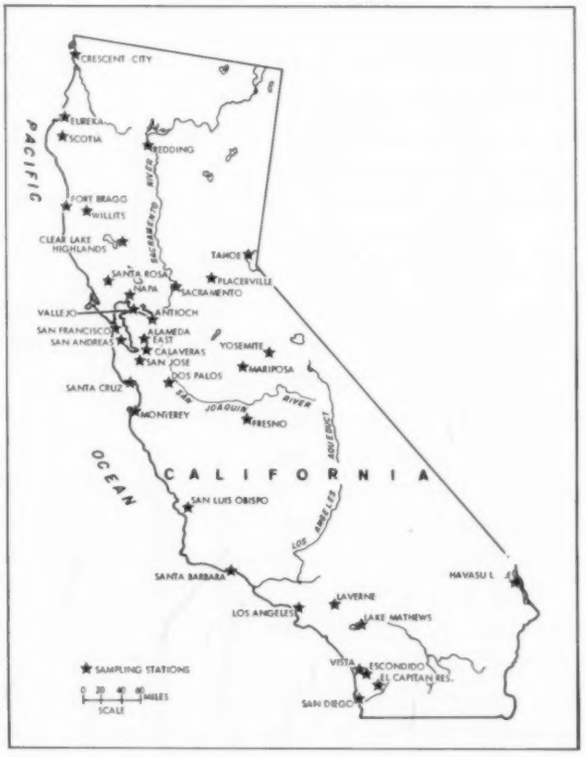

FIGURE 1.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

[1] Data from "Radiological Health News," Vol. 3 No. 2, April 1964, State of California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

TABLE 1.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, JULY–DECEMBER 1963

[Concentrations in pc/liter]

Sampling station	July	Aug.	Sept.	Oct.	Nov.	Dec.
Antioch	27.1	[a] 9.3	53.9	[a] 5.0	[a] 19.2	23.8
Chula Vista	[a] 16.0	[b]	37.5	[a] 13.0	[b] 12.3	[b] 1.0
Clearlake Highlands	[a] 19.6	[a] 5.0				[b] 4.1
Crescent City	[a] 4.2	[a] 0	[a] 6.7	38.3	[a] 0	[b] 12.2
Escondido	[a] 23.3	[a] 6.9	[a] 0	[a] 7.5	29.7	40.3
Eureka	[a] 10.7	[a] 8.6	[a] 0	[a] 13.8	[a] 12.2	[b] 16.8
Fort Bragg		[a] 1.5	[a] 9.1			[b] 16.7
Fresno						
Lake Millerton	34.2	32.5	[a] 19.0	29.3	23.8	32.3
Mariposa	[a] 13.6	[a] 0	[a] 16.4	[a] 0.2	[a] 17.6	[b] 9.7
Metropolitan Water District of Southern California						
Lake Havasu	30.3	[a] 13.8	[a] 23.2	[a] 12.3		[b] 12.2
Lake Matthews	[a] 5.1	[a] 25.6	12.4	[a] 23.7	36.2	[b] 1.6
Montrey	39.6	[a] 17.8	[a] 11.9	34.2	[b] 12.7	[b] 17.7
Napa	[a] 0	[a] 8.8			23.8	[b] 5.7
North Marin County Water District	42.3	40.6	23.7	[a] 15.4	31.4	[b] 6.3
Oroville						
Wyandotte Irrigation District		[a] 10.7		[a] 20.3		[b] 14.1
California Water Service	[a] 19.4		[a] 7.9		57.9	
Placerville		[a] 18.1	12.6		[b] 16.5	
Redding	88.0	[a] 12.9	[a] 17.9	[a] 6.5	[b] 5.5	
Sacramento	[a] 14.2	31.4	[a] 12.2	[a] 9.1	[b] 17.7	[b] 6.6
San Francisco Water Department						
Alameda East	68.0	73.1	33.3	[c] 43.2	48.8	23.6
Brightside Weir	[a] 1.3	[a] 2.8	[a] 0	[a] 0	[a] 18.6	[b] 12.6
Calaveras Reservoir	[a] 11.9	[a] 15.1	[a] 0	[a] 0	[a] 13.7	[b] 15.7
Crystal Springs Raw Outlet	[a] 6.3	15.2				
Crystal Springs Line #1		[a] [c] 18.2	[a] [c] 10.2	[a] [c] 15.2	[a] [c] 10.2	[c] 21.5
Crystal Springs Line #2				[a] [c] 22.2		
Hetch Hetchy	60.5			[a] 17.8	35.8	[b] 12.7
Lombard Reservoir	81.2					
San Andreas Line #2	[a] 6.8	[a] [c] 35.0	[a] [c] 8.3	[a] [c] 11.0	[a] 14.5	[b] [c] 15.5
San Jose	[a] 13.3	[a] 0				[b] 0
San Luis Obispo	[a] 14.4	[a] 21.0	[a] 19.6	[a] 18.1	[a] 17.6	[b] 14.7
Santa Barbara		[a] 13.7	[a] 7.8	[a] 6.5	[a] 0	35.1
Santa Cruz	26.4	[a] 15.7		[a] 3.6	[a] 3.5	[b] 12.7
Santa Rosa	100.1	[a] 0	[a] 11.5	[a] 0.7	[a] 8.0	[b] 0
Scotia	[a] 10.7	[a] 4.2	[a] 5.0	[a] 4.1	[a] 13.4	24.0
Tahoe City	22.8		30.9	[a] 4.2	[a] 5.0	[b] 3.6
Vallejo						
Fleming Hill	71.9	25.8	[a] 12.5	[a] 18.7	[a] 19.4	[b] 19.3
Swanzy Reservoir	[a] 20.0	[a] 20.4	[a] 0	[a] 19.2	[a] 8.3	[b] 20.3
Vista	60.8	[a] 24.0	[a] 8.4	[a] 24.3		[b] 11.4
Willits	[a] 16.6	[a] 9.0	[a] 0	[a] 10.2	[a] 14.5	[b] 11.0
Yosemite	45.3	24.8	23.7	21.7	22.6	24.3
Maximum	100.1	73.1	53.9	43.2	57.9	40.3
Minimum	0	0	0	0	0	0

[a] The counting rate of the sample is not equal to at least twice the 95 percent statistical counting error but the value reported is the best available estimate.
[b] Blank space indicates no sample collected or analyzed.
[c] Average of more than one sample for the month.

Laboratory Methods

Radionuclide analyses of water are carried out in the Sanitation and Radiation Laboratory. All measurements of alpha and alpha-plus-beta activities are made with windowless gas-flow proportional counters.

The Department's maximum capacity for alpha and beta radioactivity measurements during a normal work week is 500 thirty-minute counts. Counting methods used are in accordance with U. S. Public Health Service recommended procedures (*1*).

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-the-dissolved-solids in raw surface water in California from July through December 1963. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water was observed in spite of some increase in fallout.

REFERENCES

(1) Division of Radiological Health: *Radionuclide Analyses of Environmental Samples R59–6*, Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati 26, Ohio (November 16, 1959).

Previous coverage in *Radiological Health Data:*

Period	Issue
1961-June 1962	*April 1963*
July-December 1962	*September 1963*
January-June 1963	*March 1964*

RADIOACTIVITY IN NORTH CAROLINA SURFACE, GROUND, AND CISTERN WATERS, NOVEMBER 1961–DECEMBER 1963 [1]

Sanitary Engineering Division
North Carolina State Board of Health

In recognition of growing use of radioactive materials in the State of North Carolina, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health, with the cooperation of municipalities, began in June 1958 a program of measurement of radioactivity in surface waters used as public water supplies. Some 147 sampling points were established to sample raw surface water. In July 1962, the program was expanded to include the sampling of cistern water from Ocracoke Island. Then, in January 1963 other types of environmental samples were also collected (*1*), two of which were finished water from surface water supplies and ground water from wells used as municipal water supplies.

All waters contain traces of radioactivity originating from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these materials are trace elements of potassium–40, radium, thorium, and uranium. Such trace elements are dissolved by water both on its way to and flowing in the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases such as thoron and radon, are removed from the atmosphere.

The combined radioactivity of these materials constitutes what is known as "background radioactivity" of the water. The total activity would include both background radioactivity and contributions from fallout and other man-made sources.

A knowledge of the concentration of the background radioactivity as well as the total activities is an important factor in the appraisal of water quality, since standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background" (*2*). Surface water data for 1958 through 1961 are considered as background radioactivity and have previously been published in *RHD* (*3*).

[1] Abstracted from "Background Radioactivity in Surface Water Supplies in North Carolina" and "Environmental Surveillance—1963"

Laboratory Procedure

Total solids content is determined for each sample so that proper sample proportions may be used in analysis. The calculated amount of a sample is concentrated to a few millimeters on a steam bath. The residue is transferred to a stainless steel planchet and evaporated to dryness under an infrared light. After further drying for one hour at 103° C., the sample is cooled in a desiccator and is then counted.

Alpha-plus-beta counting is done in a gas-flow internal proportional counter calibrated with a radium D + E source. On the basis of instrument background (17 counts per minute), each sample is counted for a preset count and the results are reported in terms of picocuries per liter.

Results

Table 1 gives the average gross (alpha plus beta) radioactivity in raw surface water as well as the maximum and minimum values recorded over the period November 1961 through December 1963. The first column consists of code numbers which indicate the geographical positions of the sampling stations shown in figure 1.

After purification of these surface waters, the finished water is distributed for domestic and industrial uses. Finished water from some of these supplies has been sampled for gross radioactivity. Table 2 gives the average, maximum and minimum radioactivity in finished water from these supplies during 1963.

On some of the islands situated along the eastern seaboard of North Carolina (figure 2), drinking water is obtained from small cistern water supplies. The cistern supplies are characteristically constructed with roof prewash valves which permit the diversion of the first runoff and then allow the balance of the rainwater to pass into the cistern. A one-liter sample is usually collected quarterly and analyzed for gross radioactivity. Table 3 presents the results for four cistern supplies on Ocracoke Island, from the fourth quarter of

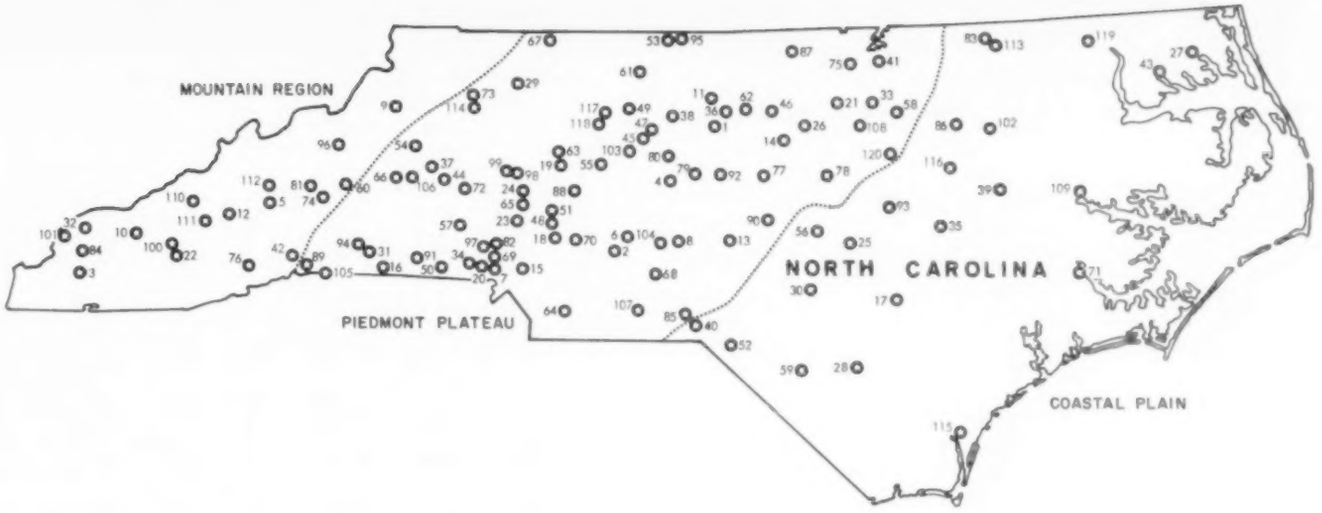

FIGURE 1.—NORTH CAROLINA REGIONS AND SURFACE WATER SAMPLING STATIONS WITH CODE NUMBERS

1962 through the fourth quarter of 1963. The location of Ocracoke Island is shown in figure 2.

FIGURE 2.—EASTERN NORTH CAROLINA, SHOWING LOCATION OF OCRACOKE ISLAND

Discussion and Interpretation of Data

The measurement of gross radioactivity (alpha-plus-beta) at low levels or low concentrations is difficult because of the many variable factors such as types and energy of radiation, necessary concentration to obtain a representative sample, and counting efficiency (which includes absorption, scatter, and geometry).

All results may be interpreted on the basis of the Public Health Service Drinking Water Standards (*4*) which state that in the absence of strontium–90 and alpha emitters, a water supply is acceptable if the gross beta activity does not exceed 1000 picocuries per liter of water. This value relates to average intake from water over a long period of time and not from transient conditions.

Individual sample data and associated errors have been separately reported (*1, 2*). The usual two-sigma counting error was from 1 to 5 pc/liter. The significant increased activity recorded in surface water from November 9, 1961, through the years 1962 and 1963 is probably due to the presence of fission material produced during the renewed atmospheric testing of nuclear weapons. The network average radioactivity in surface water was about the same in 1963 as in 1962.

TABLE 1.—GROSS RADIOACTIVITY FOUND IN RAW SURFACE WATER USED AS SOURCES OF PUBLIC WATER SUPPLIES, NORTH CAROLINA, NOVEMBER 1961–DECEMBER 1963

[Alpha-plus-beta concentrations in pc/liter]

Code	Location	Source of water supply	November 1961—1962				1963			
			No. of samples	Average	Maximum [a]	Minimum [b]	No. of samples	Average	Maximum [a]	Minimum [b]
1	Alamance	Big Alamance Creek	0	—	—	—	2	7.7	8.3	7.1
2	Albemarle	Yadkin River	12	17.5	36.6	4.7	12	11.6	21.5	4.7
3	Andrews	Beaver Creek	5	2.9	5.8	1.4	2	1.6	2.3	1.0
4	Asheboro	Back Creek	5	27.9	44.5	19.6	4	24.1	32.1	9.3
5	Asheville	Bee Tree Creek	11	2.9	8.0	1.4	13	7.2	15.1	2.0
6	Badin	Yadkin River	5	21.1	46.2	6.9	1	7.6	7.6	7.6
7	Belmont	Catawba River	5	25.6	53.3	6.1	4	11.6	16.4	6.2
8	Biscoe	Little River	5	11.9	18.4	5.9	3	45.7	109.8	11.1
9	Blowing Rock	Brickhouse Creek	12	12.8	28.6	7.0	4	13.6	26.6	7.2
10	Bryson City	Lands Creek	5	1.4	1.8	1.0	2	7.6	13.7	1.6
11	Burlington	Stony Creek	0	—	—	—	12	26.0	58.7	8.0
12	Canton	Pigeon River; Ruff Creek	4	5.7	6.4	3.0	2	2.8	3.3	2.4
13	Carthage	Spring	5	5.0	7.2	3.3	0	—	—	—
14	Chapel Hill	Price Creek	5	22.4	44.7	10.0	4	20.8	33.1	8.1
15	Charlotte	Catawba River	14	13.8	32.9	3.7	12	13.8	27.5	2.9
16	Cliffside	Second Broad River	13	14.0	90.0	0.9	4	7.1	10.2	0.9
17	Clinton	Black River	10	19.0	34.1	7.6	4	12.2	25.6	1.5
18	Concord	Cold Water Creek & Lumby Creek	13	36.7	79.4	7.0	12	28.0	64.4	10.4
19	Cooleemee	South Fork Yadkin	5	12.3	43.4	6.1	4	13.3	21.3	3.4
20	Cramerton	South Fork Catawba River	5	19.0	54.1	5.5	12	9.5	24.0	3.2
21	Creedmoor	Ledge Creek	5	42.5	74.5	6.4	2	33.4	57.1	9.7
22	Cullowhee	Long Branch; Flat Creek	5	3.9	10.4	2.4	2	0.9	1.7	0.1
23	Davidson	Cathy's Creek	5	13.7	27.7	9.0	2	7.6	10.2	5.0
24	Denton	Lick Branch	5	27.0	38.9	8.7	2	17.0	29.8	4.1
25	Dunn	Cape Fear River	12	40.3	119.0	11.6	4	22.9	33.7	11.3
26	Durham	Flat River	11	30.8	64.2	9.2	13	25.5	69.2	12.3
27	Elizabeth City	Pasquotank River	5	11.6	26.3	5.0	1	3.6	3.6	3.6
29	Elkin	Big Elkin Creek	5	12.0	17.3	4.8	2	4.6	6.8	2.4
30	Fayetteville	Cape Fear River	13	24.2	57.1	7.6	12	43.4	145.5	4.0
31	Forest City	Second Broad River	5	10.6	26.0	1.5	3	5.2	7.5	2.8
32	Fontana Dam	Little Tennessee River	5	7.0	10.4	3.9	2	5.5	6.0	5.0
33	Franklinton	Kearney's Creek	6	28.7	50.4	6.2	2	22.2	37.6	6.7
34	Gastonia	Long Creek; Catawba River	13	17.0	38.4	4.2	12	14.4	46.4	3.2
35	Goldsboro	Little River; Neuse River	0	—	—	—	3	15.7	23.9	10.7
36	Graham	Back Creek	5	20.3	[c] 42.6	10.2	3	16.4	28.2	7.3
37	Granite Falls	Catawba River	5	11.2	18.1	2.8	2	8.8	13.4	4.2
38	Greensboro	Reedy Fork Creek	13	29.4	62.6	7.4	12	30.1	73.0	7.8
39	Greenville	Tar River	10	29.5	[d] 69.4	12.0	21	18.6	42.3	5.1
40	Hamlet	Marks Creek	5	12.4	25.6	2.1	2	22.6	36.6	8.6
41	Henderson	Sandy Creek	4	19.0	33.8	8.7	2	23.4	30.1	16.7
42	Hendersonville	North Fork Mills River and Bradley Creek	0	—	—	—	3	2.8	4.1	2.0
43	Hertford	Perquimans River	5	7.6	15.3	0.0	1	2.8	2.8	2.8
44	Hickory	Catawba River	12	7.9	17.3	3.9	12	8.2	16.7	2.8
45	High Point	Deep River	11	43.4	110.2	9.1	12	24.9	68.7	6.5
46	Hillsboro	Eno River	5	15.8	36.3	4.1	4	14.6	25.4	6.7
47	Jamestown	Deep River	3	29.2	53.2	15.3	1	22.6	22.6	22.6
48	Kannapolis	Buffalo Creek	12	26.1	54.0	8.0	12	24.2	41.9	7.0
49	Kernersville	Belew's Creek	7	33.2	58.3	9.1	2	11.2	15.6	6.7
50	Kings Mountain	Kings Creek	5	23.2	59.9	4.5	2	12.8	18.6	7.0
51	Landis	Grant's Creek	5	45.4	75.3	8.4	2	14.3	17.6	11.1
52	Laurinburg	Jordan Creek	5	11.1	16.9	5.2	12	12.1	29.0	4.5
53	Leaksville	Dan River	12	15.7	35.0	3.9	4	9.8	19.0	4.8
54	Lenoir	Zacks Fork Creek & Catawba River	5	10.6	17.8	4.9	3	12.0	13.6	8.9
55	Lexington	Abbott's Creek	5	39.0	70.1	8.0	4	32.3	41.6	24.9
56	Lillington	Cape Fear River	5	35.4	85.0	7.8	2	13.8	16.3	10.4
57	Lincolnton	Walker Branch	6	36.5	145.7	2.7	4	17.4	41.2	1.8
58	Louisburg	Tar River	3	40.4	67.4	18.6	2	12.0	14.6	9.5
59	Lumberton	Lumber River	11	22.7	54.8	5.0	12	16.3	31.9	8.1
60	Marion	Mackey's Creek; Buck Creek	5	7.1	23.0	0.8	1	6.5	6.5	6.5
61	Mayodan	Mayo River	5	13.2	32.8	6.3	1	28.7	28.7	28.7
62	Mebane	Mills Creek	5	11.9	18.1	4.5	1	13.2	13.2	13.2
63	Mocksville	Bear Creek	5	30.1	97.6	6.2	0	—	—	—
64	Monroe	Richardson Creek	5	42.6	76.4	31.4	4	32.9	61.6	5.1
65	Mooresville	Byers Creek; Catawba River	7	15.7	43.5	4.5	4	11.9	17.7	4.7
66	Morganton	Henry River	6	2.4	3.5	1.1	3	3.0	5.2	1.1
67	Mount Airy	Lovell's Creek	1	5.4	5.4	5.4	4	4.4	6.2	2.4
68	Mount Gilead	Pee Dee River	5	22.6	40.2	11.0	4	13.8	22.0	6.0
69	Mount Holly	Catawba River	5	16.2	31.8	7.8	12	11.4	15.8	6.4
70	Mount Pleasant	Dutch Buffalo Creek	6	11.8	17.9	6.0	1	26.0	26.0	26.0
71	New Bern	Neuse River	8	17.5	38.4	6.3	1	11.9	11.9	11.9
72	Newton	Jacobs Fork	0	—	—	—	3	17.7	35.5	5.6
73	North Wilkesboro	Reddies River	12	9.0	40.9	2.4	4	15.9	46.1	1.6
74	Old Fort	Jarrett Creek	5	7.8	18.1	2.6	0	—	—	—
75	Oxford	Tar River; Hatcher's Run	6	54.3	89.6	9.6	1	27.8	27.8	27.8
76	Pisgah Forest	Davidson River	8	4.8	9.2	1.4	1	14.8	14.8	14.8
77	Pittsboro	Robinson Creek	5	46.3	100.7	16.2	2	45.6	61.0	26.3
78	Raleigh	Lake Raleigh; Lake Wheeler	0	—	—	—	9	30.0	54.8	11.3
79	Ramseur	Sandy Creek	6	10.7	34.0	4.3	1	23.2	23.2	23.2
80	Randleman	Pole Cat Creek	6	18.9	47.2	4.4	1	51.6	51.6	51.6

TABLE 1.—Continued.

[Alpha-plus-beta concentrations in pc/liter]

Code	Location	Source of water supply	November 1961—1962				1963			
			No. of samples	Average	Maximum [a]	Minimum [b]	No. of samples	Average	Maximum [a]	Minimum [b]
81	Ridgecrest	Mountain Stream	5	3.6	4.7	2.9	0	—	—	—
82	Riverbend	Catawba River	4	23.9	43.6	7.8	1	19.6	19.6	19.6
83	Roanoke Rapids	Roanoke River	12	15.1	28.8	8.0	4	12.0	18.6	5.6
84	Robbinsville	Rock & Burgin's Creek	4	7.7	23.7	1.3	0	—	—	—
85	Rockingham	Falling Creek	5	2.0	2.1	1.4	4	25.3	36.0	11.6
86	Rocky Mount	Tar River	0	—	—	—	10	25.0	78.7	6.4
87	Roxboro	Lake Issac Walton; Storey's Creek	6	25.0	50.9	9.5	1	13.4	13.4	13.4
88	Salisbury	Yadkin River	4	4.8	8.6	0.9	11	16.3	48.2	2.8
89	Saluda	Paces Creek	4	4.7	8.6	2.0	0	—	—	—
90	Sanford	Lick Creek; Potterage Creek	6	15.3	25.0	7.6	4	17.9	37.0	10.3
91	Shelby	First Broad River	11	19.6	43.5	3.7	4	7.3	9.4	4.9
92	Siler City	Rocky River	5	53.5	86.8	14.0	4	21.7	34.7	11.4
93	Smithfield	Neuse River	12	25.5	94.7	5.6	11	26.5	56.9	12.6
94	Spindale-Rutherfordton	Hollands Creek; Cathy's Creek	5	12.7	46.2	2.2	1	4.4	4.4	4.4
95	Spray	Smith River	13	15.1	46.8	4.1	12	19.4	101.6	1.7
96	Spruce Pine	Beaver Creek	5	2.9	7.1	1.5	0	—	—	—
97	Stanley	Hoyle's Creek	6	11.8	32.1	3.3	1	32.3	32.3	32.3
98	Statesville	Fourth Creek	5	15.0	62.2	1.1	4	8.1	14.5	3.0
99	Statesville	South Yadkin River	5	21.1	85.3	3.7	5	6.6	9.4	3.6
100	Sylva	Dill's Creek	12	2.7	5.1	0.6	4	3.9	6.8	1.6
101	Tapoco	Yellow Hammer Creek	5	3.3	5.9	1.7	1	4.8	4.8	4.8
102	Tarboro	Tar River	5	38.1	58.4	10.6	4	15.4	32.2	6.8
103	Thomasville	Abbott's Creek	7	32.0	68.8	19.1	4	25.9	37.6	6.2
104	Troy	Denson Creek; Downing Creek	6	7.5	10.5	4.0	1	20.5	20.5	20.5
105	Tryon	Falls Creek; Vaughn's Creek	6	4.4	17.8	2.3	1	4.4	4.4	4.4
106	Valdese	Micol Creek; Hoyle Creek; Catawba River	4	14.3	34.4	3.6	4	9.1	14.5	3.4
107	Wadesboro	Jones Creek	5	34.7	77.6	12.1	1	28.0	28.0	28.0
108	Wake Forest	Smith's Creek	3	10.0	13.0	6.7	1	13.5	13.5	13.5
109	Washington	Tranters Creek	5	37.9	46.5	23.2	1	27.3	27.3	27.3
110	Waterville	Big Creek	4	1.3	1.7	1.0	1	0.8	0.8	0.8
111	Waynesville	Cherry Cive & Shiney Creek	4	6.8	14.4	2.5	2	6.8	8.5	5.3
112	Weaverville	Wagner Branch & Ox Creek	4	2.1	2.8	1.8	1	2.6	2.6	2.6
113	Weldon	Roanoke River	4	29.8	70.6	13.6	1	14.5	14.5	14.5
114	Wilkesboro	Cub Creek	5	6.1	12.4	2.4	1	2.1	2.1	2.1
115	Wilmington	Cape Fear River	12	27.2	85.6	8.3	11	20.8	57.9	11.8
116	Wilson	Contentney Creek	7	24.6	28.6	20.9	0	—	—	—
117	Winston-Salem	Salem Creek	13	19.2	44.5	3.9	9	23.6	36.3	0.8
118	Winston-Salem	Yadkin River	11	13.4	72.0	3.5	10	27.0	35.3	2.3
119	Winton	Chowan River	9	28.4	43.8	15.3	1	16.0	16.0	16.0
120	Zebulon	Little River	5	23.7	77.5	5.5	4	9.9	11.4	7.7
Network summary			757	18.7	145.7	0.0	509	16.2	145.5	0.1

[a] Maximum values have 95 percent accuracy ±20 percent.
[b] Minimum values have 95 percent accuracy ±60 percent.
[c] A value of 156 pc/liter was observed but probably reflects rainfall and was excluded.
[d] A value of 368 pc/liter was observed but probably reflects rainfall and was excluded.

The results for 1963 for ground water, raw surface water, finished water, and cistern water have been summarized in table 4, by region of the State (figure 1).

It is apparent that the coastal region has somewhat greater radioactivity in its ground water than the Piedmont and mountain regions as indicated by averages of 11, 6, and 5 pc/liter, respectively. These activities would be considered as background since the radioactivity present in the water is imparted to the ground waters from the dissolution of geological formations of granite, gneiss, and other bedrock. Radioactivity so imparted would be the combined contribution of such elements as natural uranium, thorium, radium, potassium and other long-lived materials occurring in nature.

It can be noted that the mountain surface waters contain less radioactivity (6 pc/liter) than those in the Piedmont (19 pc/liter) and further east (20 pc/liter). This is to be expected, since the surface waters in the mountains have less mineral content. As these waters flow toward the ocean their dissolved solids content, paralleled by their concentrations of natural radioactivity as well as fallout activity, increases.

The mountain region had an average of 6 pc/liter in finished water while the Piedmont and coastal regions reported averages of 9 and 12 pc/liter. In order to directly compare the results for raw water and finished water, one should refer to the data for individual samples of raw and finished water collected at the same time (*2*). However, it appears that finished

TABLE 2. GROSS RADIOACTIVITY IN FINISHED WATER FROM SURFACE WATER SUPPLIES IN NORTH CAROLINA, 1963

[Alpha-plus-beta concentrations in pc/liter]

Code No.	Location	Source of water supply	No. of samples surveyed	Average	Maximum	Minimum
2	Albemarle	Yalkin River	12	7.1	12.3	2.5
5	Asheville	Bee Tree Creek	11	5.3	10.1	1.4
11	Burlington	Stony Creek	12	12.4	19.4	6.6
15	Charlotte	Catawba River	18	8.3	10.6	5.6
18	Concord	Cold water Creek and Lumby Creek	12	14.2	31.6	6.6
20	Cramerton	South Fork Catawba River	12	5.0	18.7	1.2
26	Durham	Flat River	12	10.1	17.4	5.0
30	Fayetteville	Cape Fear River	12	12.7	35.1	5.9
34	Gastonia	Long Creek; Catawba River	12	8.1	13.9	3.2
35	Goldsboro	Little River; Neuse River	3	25.2	61.8	3.5
38	Greenboro	Reedy Fork Creek	12	9.9	16.6	4.8
39	Greenville	Tar River	14	9.0	16.8	4.8
44	Hickory	Catawba River	12	6.5	12.8	2.7
45	High Point	Deep River	12	10.4	14.6	4.9
48	Kannapolis	Buffalo Creek	13	11.2	16.0	4.3
52	Laurinburg	Jordan Creek	11	4.9	7.2	2.0
59	Lumberton	Lumber River	12	8.7	16.1	3.3
69	Mount Holly	Catawba River	12	7.3	15.5	4.3
78	Raleigh	Lake Raleigh; Lake Wheeler	12	12.8	26.3	4.8
86	Rocky Mount	Tar River	12	9.2	17.8	3.2
88	Salisbury	Yadkin River	11	6.5	9.1	3.8
93	Smithfield	Neuse River	11	11.6	27.8	3.5
95	Spray	Smith River	12	5.3	9.2	2.5
115	Wilmington	Cape Fear River	11	10.4	17.4	4.8
117	Winston Salem	Salem Creek	9	7.6	10.8	4.3
118	Winston Salem	Yadkin River	5	9.0	13.0	4.4
Network summary			297	9.6	61.8	1.2

TABLE 3.—GROSS RADIOACTIVITY IN CISTERN WATER AT OCRACOKE ISLAND, NORTH CAROLINA, DECEMBER 1962–DECEMBER 1963

[Alpha-plus-beta concentrations in pc/liter]

Date sampled	Type of supply			
	Public school	National Park Service	Coast Guard station	Private residence
December 16, 1962	68.6	124.4	130.9	115.2
April 8, 1963	98.4	82.5	278.3	226.0
May 27, 1963	140.7	163.8	272.2	19.0
July 19, 1963	169.2	[a]—	230.6	—
December 2, 1963	33.7	35.8	85.4	58.6

[a] Dash indicates no sample.

TABLE 4.—SUMMARY OF RESULTS OF GROSS RADIOACTIVITY IN WATER SUPPLIES IN NORTH CAROLINA 1963

[Alpha-plus-beta concentrations in pc/liter]

Type of water and region	No. of samples	Average	Maximum	Minimum
Ground water				
Mountain region	25	5	14	1
Piedmont region	47	6	13	1
Coastal region	95	11	55	1
Raw surface water				
Mountain region	88	6	18	0
Piedmont region	332	19	109	1
Coastal region	115	20	42	2
Finished water from surface supplies				
Mountain region	11	6	9	4
Piedmont region	202	9	34	2
Coastal region	87	12	21	2
Cistern water				
Ocracoke Island	14	135	278	19

water had on the average lower concentrations than raw water.

It is readily apparent that during 1963 cistern water contained more radioactivity than any of the other types of public water supplies sampled. The range observed was from 19 to 278 pc/liter with an average of 135 pc/liter. These values are more nearly like the values usually observed in precipitation during 1963 than the values for ground and surface water. This may be due to fission products being washed from the atmosphere and from roofs by precipitation.

REFERENCES:

(1) North Carolina State Board of Health Sanitary Engineering Division and State Laboratory of Hygiene: *Background Radioactivity in Surface Water Supplies of North Carolina, 1958–1962.*

(2) North Carolina State Board of Health Sanitary Engineering Division and State Laboratory of Hygiene: *Environmental Surveillance—1963.*

(3) North Carolina State Board of Health, Sanitary Engineering Division: North Carolina Surface Water, June 1958–December 1961, *Radiological Health Data*, 4:259–62 (May 1963).

(4) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

Previous coverage in *Radiological Health Data:*

Period	Issue
June-August 1962 (cistern water)	*February 1963*
June 1958-December 1961	*May 1963*

Section IV—Other Data

SUMMARY OF STATE RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE ACTIVITIES

Carnick A. Markarian, George W. Williams, and Guntis Ozolins[1]

In the past five years, considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed significantly toward achievement of a comprehensive environmental surveillance program and self-sustaining radiological health laboratory. Although a few States have encountered difficulties (mainly personnel and budgetary) in their attempts to initiate such programs, a recent status review showed that 44 States were conducting some form of surveillance by mid-1963.

A graphical summary of State sampling programs is presented and a description of laboratory capabilities and activities follows. The data discussed in the sections on sampling, equipment and analyses were derived from State status reports dated June 30, 1963.[2] The data pertaining to the nuclide distribution and the quality control program are inclusive through May 31, 1964. A detailed evaluation of the latter program and individual State programs are beyond the scope of this summary.

Sample Collection

Shaded portions of figures 1–4 indicate those States which have established air, precipitation, milk and water programs. The total sampling locations in each State is indicated by numbers inscribed within symbols which designate frequency of collection. Routine surveillance activities reflected in the figures may be expanded whenever levels of contamination indicate the need for more extensive surveillance. In addition, some States are conducting sampling of food, shellfish, aquatic biota and other vectors.

The frequency of sampling of a given vector is not necessarily constant within a State. A sampling program may include several daily samples as well as samples collected at longer intervals. The attempt in such cases is to show the predominant sampling frequency. Air is being sampled in 26 States (shown in figure 1), with collection frequencies ranging from daily, the most common, to twice a month. Precipitation sampling is conducted in 15 States at daily or weekly collection intervals as shown in figure 2.

Milk samples are collected by 27 States for analysis. The frequency of collection varies from daily to quarterly. Analyses are usually performed on composite samples collected from individual major dairies or from milk processing plants within a milkshed area. The number of sampling points shown in figure 3 indicates the number of milksheds under surveillance.

Raw surface water and public water supply sampling points have been combined in water surveillance activities (figure 4). A total of 41 States have indicated participation in water sampling, of which 27 State programs include both raw and public supply sampling. Eleven States are sampling only raw surface water, and three are engaged only in surveillance of the public supply. The sampling frequencies cover a very wide span—from daily to once every three years. Almost all of the sampling is performed on a "grab" basis, and the grab samples are either composited for analysis or analyzed separately. One State (Georgia) has indicated use of continuous composite samplers in its water surveillance program.

Analytical Capabilities

Gamma spectroscopy, gross beta counting equipment, and radiochemistry are being employed by the State laboratories. Availability of gamma spectroscopy equipment and low-background beta counters was selected as an index of State program laboratory capabilities.

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[1] Mr. Markarian is Chief, and Messrs. Williams and Ozolins are staff members of the State Surveillance Program, State Assistance Branch, Division of Radiological Health, Public Health Service, Department of Health, Education and Welfare, Washington, D. C.

[2] Milk sampling information is current through August 1964.

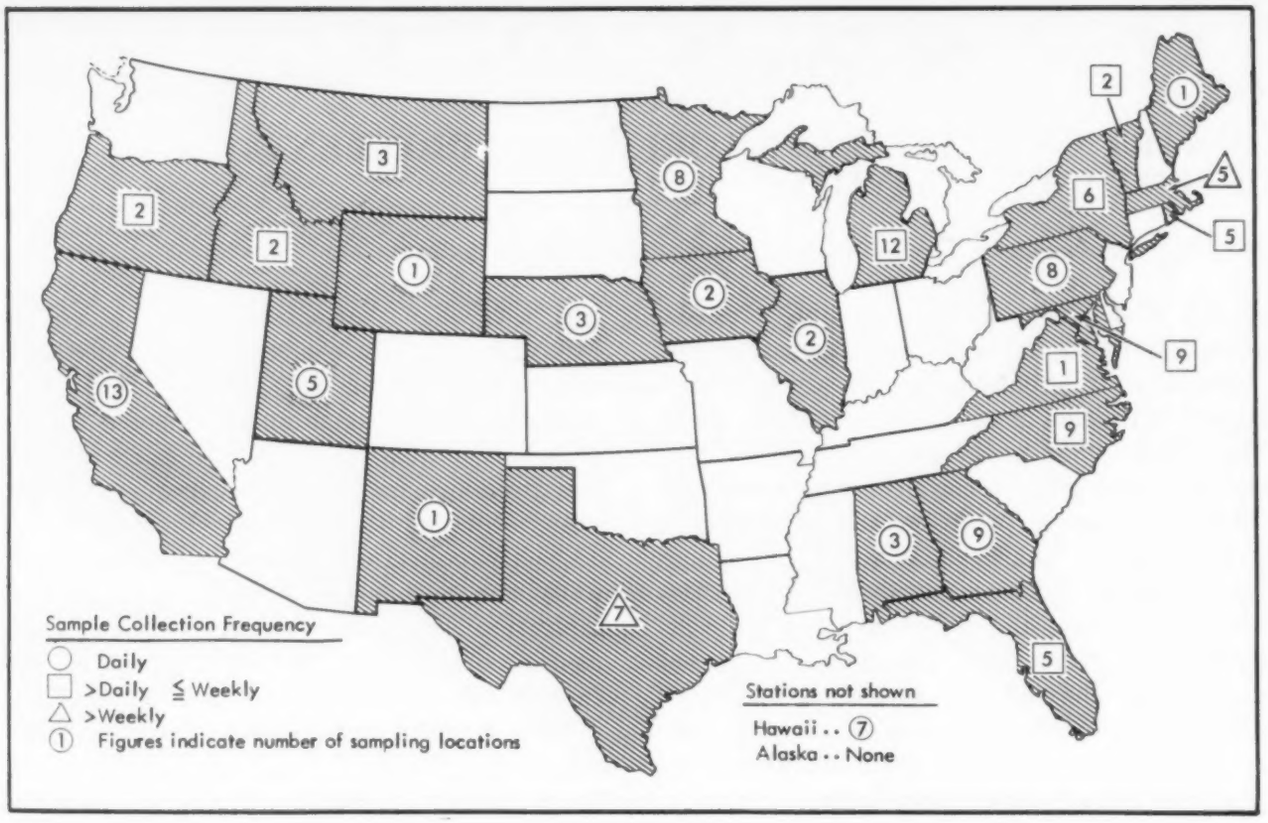

FIGURE 1.—AIR SAMPLING STATIONS, JUNE 1963

Sample Collection Frequency
Daily, at times of precipitation
Weekly, at times of precipitation
Figures indicate number of sampling locations
* Collection interval unknown
Stations not shown
Hawaii .. (7)
Alaska .. None

FIGURE 2.—PRECIPITATION SAMPLING STATIONS, JUNE 1963

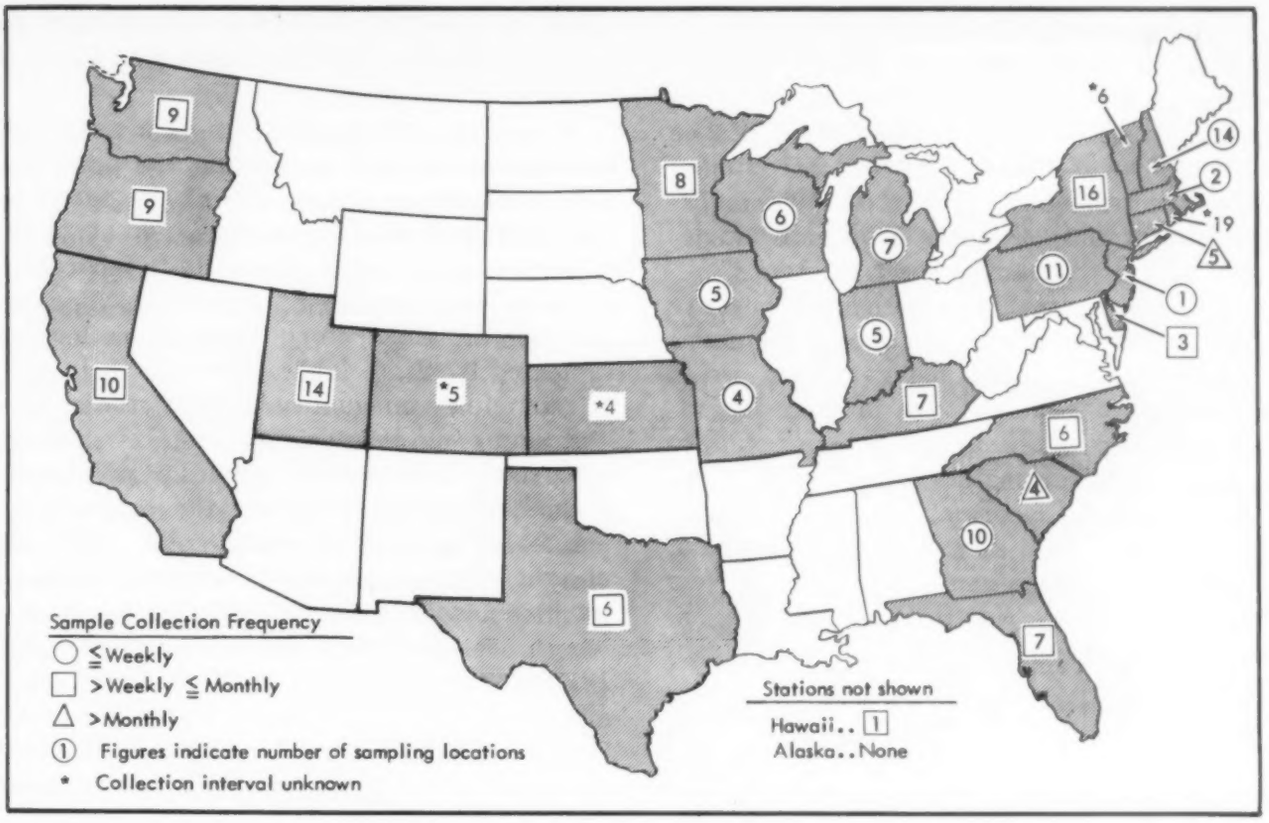

FIGURE 3.—MILK SAMPLING STATIONS, AUGUST 1964

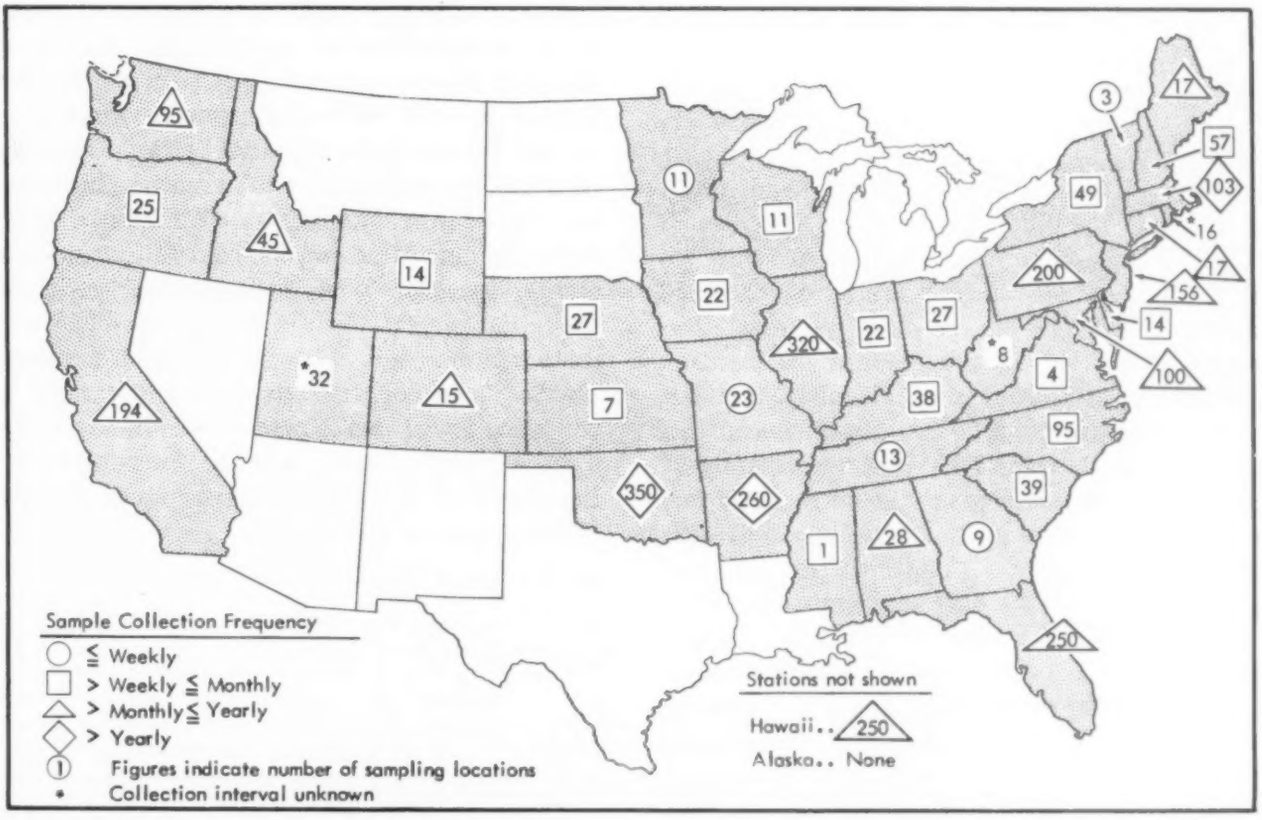

FIGURE 4.—WATER SAMPLING STATIONS, JUNE 1963

Gamma spectrometers—single channel, multichannel, or both—are now present in the laboratories of 38 States. (Two of the spectrometers were on order at the time of the status reports.) Nine States have single-channel spectrometers, 15 States have multichannel units and 14 States have both single-channel and multichannel spectrometers.

Twenty-five States have indicated they are equipped with low-background beta counters, and two additional States have these on order. The following 22 States have in their laboratories both the low-background beta counters and gamma spectrometers: California, Connecticut, Florida, Georgia, Hawaii, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Texas, and Washington.

There are differences between States as to type and extent of analyses performed for different environmental radiation vectors; i.e., one State may measure only the gross beta activity on air samples, whereas another State may also perform gross alpha and a gamma scan. Table 1 summarizes the general types of analyses performed by the State laboratories.

The process of instrument calibration includes the selection and acquisition of standards and the application of these for the determination of the efficiencies of the counting equipment. These standards have been available to the State laboratories from agencies of the U. S. Government as well as private industry. During the period from March 1963 to May 31, 1963, 36 States have requested and received over 200 standards for calibration purposes from the Public Health Service. Cesium–137, radium–226, cerium–144, zinc–65, cobalt–60, ruthenium–106 and strontium–90 have been the nuclides requested most frequently during this period. During the early stages of operation, some States have requested and received outside assistance in calibration of gamma spectrometers.

A quality control program is a useful tool in determining and increasing the uniformity and reliability in the results of the participating laboratories. Cross-checking of results may be of great value especially to laboratories in their early stages of operation. The need for such interlaboratory comparisons has been indicated by State laboratories by their desire to participate in quality control studies.

Recognizing the need for obtaining comparable data, 11 State laboratories participated in a quality control program for evaluation of iodine–131 measurements in milk. Milk samples of known iodine–131 content were distributed by the Public Health Service to these laboratories for their measurement of iodine–131 concentration. The quality control studies are being conducted by the Analytical Quality Control Service at the Northeastern Radiological Health Laboratory, Winchester Massachusetts.

Remarks

The status of State environmental surveillance programs is continually undergoing changes dependent upon the prevalence of potential sources of contamination, fluctuations in the levels of radioactivity, availability of personnel and support for initiating or expanding surveillance programs. While earlier surveillance activities emphasized fallout measurements, interest is now expanding to include surveillance activities in the vicinity of nuclear installations such as reactors and processing plants. Another fundamental concern of surveillance programs is that of producing reliable measurements, and this is currently being implemented through further participation in quality control studies.

TABLE 1.—TYPES OF ANALYSES PERFORMED BY STATE LABORATORIES

Environmental media	Number of States participating					
	Sampling programs	Analyses				
		Gross alpha	Gross beta	Gamma scan	Strontium-89	Strontium-90
Air	26	8	26	6	0	0
Precipitation	15	9	15	6	0	0
Milk	27	0	0	22	14	21
Water	41	30	39	8	0	0

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. The environmental monitoring summaries for Calendar Year 1963 for the Atomics International facility, National Reactor Testing Station and Pinellas Peninsula Plant are presented below.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1. Total alpha data in the Atomics International and National Reactor Test Station reports may be compared with the standards on line 2 in table 1. Total beta activity may be compared with lines 1 and 3. Additionally the Federal Radiation Council daily intake guides for iodine–131, strontium–89, and strontium–90 are noted.

TABLE 1.—CONCENTRATION STANDARDS [a] PERTAINING TO ENVIRONMENTAL MONITORING AT INSTALLATIONS REFERRED TO IN TEXT

Line No.	Radionuclide or mixture of radionuclides	Air (pc/m³)	Water (pc/liter)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, and Th-nat are not present [b]	—	2,000
2	Mixtures of unidentified nuclides	0.04	10
3	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present [b]	100	—
4	Hydrogen-3 (tritium)	500,000	3,000,000
5	Iodine-131 [c]	300	2,000
6	Strontium-90 [c]	10	100
7	Cesium-137	500	20,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small (<10%) compared with its appropriate MPC. See Federal Register, Title 10, Part 20, August 9, 1961.

[c] Daily intake guides recommended by the Federal Radiation Council (top of range II) are: iodine-131, 100 pc/day; strontium-89, 2000 pc/day; and strontium-90, 200 pc/day.

1. ATOMICS INTERNATIONAL
Calendar Year 1963

Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops, and constructs nuclear reactors for control stations, compact power plants, and medical, industrial, and scientific applications. Locations of the facilities are shown in figure 1.

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor; several smaller experimental reactor facilities such as critical facilities, Systems for Nuclear Auxiliary Power (SNAP) reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building, but a small amount of fuel fabrication is conducted there. For this reason, the WHF area is included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design. Surface soil, vegetation, water and air samples are surveyed periodically.

Air Monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours and counted in an automatic proportional counting system. The volume of a typical daily air sample is approximately 21 cubic meters. The minimum detection limit is on the order of 0.02 pc/m³. Averages for beta-gamma activity in airborne particulates are given in table 2.

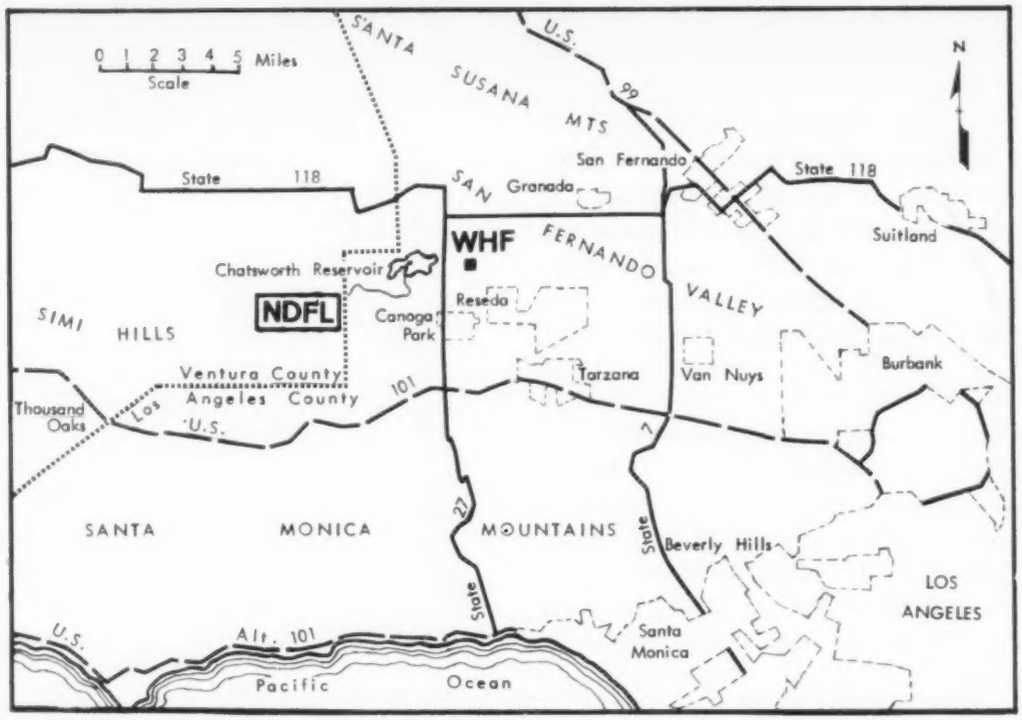

FIGURE 1.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

TABLE 2.—AIRBORNE RADIOACTIVITY DATA—1963 SEMIANNUAL AVERAGE

[β-γ activity in pc/m^3]

Site	First half 1963		Second half 1963	
	Number of samples	Average concentration	Number of samples	Average concentration
Headquarters	179	9.6	181	3.7
NDFL	141	6.9	151	2.7

Water Samples

Process water at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Monthly samples are collected from these wells (see table 3). Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one liter polyethylene bottles for transfer to the laboratory. Water samples from the lake surface and supply inlet of Chatsworth Reservoir are similarly obtained (see table 4).

TABLE 3.—WELL WATER MONITORING, NDFL, 1963

[pc/liter]

Activity	First half 1963		Second half 1963	
	Number of samples	Average	Number of samples	Average
α	12	[a] 0.23	12	[a] 0.13
β-γ	12	10	12	[a] 4.3

[a] Rounded from range of values originally reported.

TABLE 4.—CHATSWORTH RESERVOIR WATER SAMPLING, 1963

[pc/liter]

Sample	Activity	First half 1963		Second half 1963	
		Number of samples	Average	Number of samples	Average
Lake surface	α	24	0.75	13	1.0
	β-γ	24	19	13	16
Supply inlet	α	6	0.46	6	0.69
	β-γ	6	[a] 10.5	6	7.8

[a] Rounded from range of values originally reported.

In the laboratory, 500 ml. of water are evaporated to dryness in crystallizing dishes at approximately 90° C. The residue salts are transferred into stainless steel planchets,

vetted to produce an even sample distribution, edried under infrared lamps, and counted in n automatic proportional counting system.

Soil and Vegetation Samples

Soil and vegetation are sampled monthly at 51 locations. Thirteen sampling stations are located within the boundaries of Atomics International and are designated as on-site stations. The remaining 38 stations are located within a 10-mile radius of Atomics International and are referred to as off-site stations. Several of the off-site stations are located at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power.

Surface soil samples range from decomposed granite to clay and loam and are collected from the top half-inch layer of ground surface. The samples are placed in plastic containers and sent to the laboratory. Sample preparation consists of drying the soil in a muffle furnace at 500° C. for approximately eight hours, cooling, and sieving to obtain uniform particles for counting. One-gram aliquots of the soil are put in stainless steel planchets, wetted with acetone, redried, and counted in an automatic proportional counting system. Alpha and beta-gamma activities of soil samples are given in table 5.

TABLE 5.—SOIL RADIOACTIVITY, 1963

[pc/g]

Area	Activity	First half 1963		Second half 1963	
		Number of samples	Average	Number of samples	Average
On-site	α	78	[a] 0.44	78	[a] 0.42
	β-γ	78	44	78	45
Off-site	α	227	[a] 0.41	228	[a] 0.37
	β-γ	227	41	228	44

[a] Rounded from range of values originally reported.

Vegetation samples obtained in the field at each station are generally sunflower or wild tobacco plant leaves. At the laboratory the leaves are stripped from the plant and washed to remove foreign matter. The vegetation, after a distilled water rinse, is ashed in a muffle furnace at 500° C. for approximately eight hours, thus producing a completely oxidized ash of uniform density. Three-hundred milligram aliquots of ground ash are used for counting in an automatic proportional counting system. Vegetation data are shown in table 6.

TABLE 6.—RADIOACTIVITY IN VEGETATION, 1963

[pc/gm ash]

Area	Activity	First half 1963		Second half 1963	
		Number of samples	Average	Number of samples	Average
On-site	α	78	[a] 0.52	78	[a] 0.36
	β-γ	78	558	78	373
Off-site	α	228	[a] 0.45	228	[a] 0.29
	β-γ	228	489	228	287

[a] Rounded from range of values originally reported.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960 and first and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*August 1962*
Calendar year 1962	*November 1963*

2. NATIONAL REACTOR TESTING STATION
Calendar Year 1963

Health and Safety Division
Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area which, in a large measure, permits controlled releases of radioactivity from the projects with minimum risk to the environs.

Responsibility for holding the environmental radioactivity levels at the station below the Radiation Protection Guides (RPG) recommended by the Federal Radiation Council (FRC) lies with the Atomic Energy Commission. One of the safeguards employed is a monitoring program. Descriptions of the monitoring network procedures have been presented earlier (see previous coverage). Quarterly environmental monitoring results, in addition to calendar year averages for 1963, are shown in table 7. Sampling locations at NRTS can be seen in figure 2.

TABLE 7.—ENVIRONMENTAL MONITORING PROGRAM DATA, NRTS, 1963

Type of sample and units	No. of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	1963 Quarterly averages				1963 Calendar year summary
					First quarter	Second quarter	Third quarter	Fourth quarter	
Off-site underground water (pc/liter)	32	Three months	α	3	<4	<3	<4	<4	<4
			β	6	<20	<30	<40	<20	<30
			H^3	4000	<4000	<4000	<4000	<4000	<4000
On-site production well water (pc/liter)	22	Two weeks	α	3	4	<4	<3	<4	<4
			β	6	20	<20	<20	<20	<20
			H^3	4000	<7000	<7000	<8000	<8000	<7000
Off-site air filters (pc/m³)	14	weekly	β	(not given)	20	23	12	5	15
Off-site milk (pc/liter)	13	monthly	I^{131}	[a] 20	12	<10	<20	<20	<20
	10	monthly [b]	Sr^{90}	1.5	10	36	30	23	25
Off-site area monitoring badges (mrem)	14	monthly [c]	α	10	<30	<40	<30	<30	<140
			β	10	<30	<30	<30	<30	<120

[a] Changed from 10 to 20 in August of 1963.
[b] Changed from 2 months to monthly in 1963.
[c] Changed from 6 weeks to monthly in 1963.

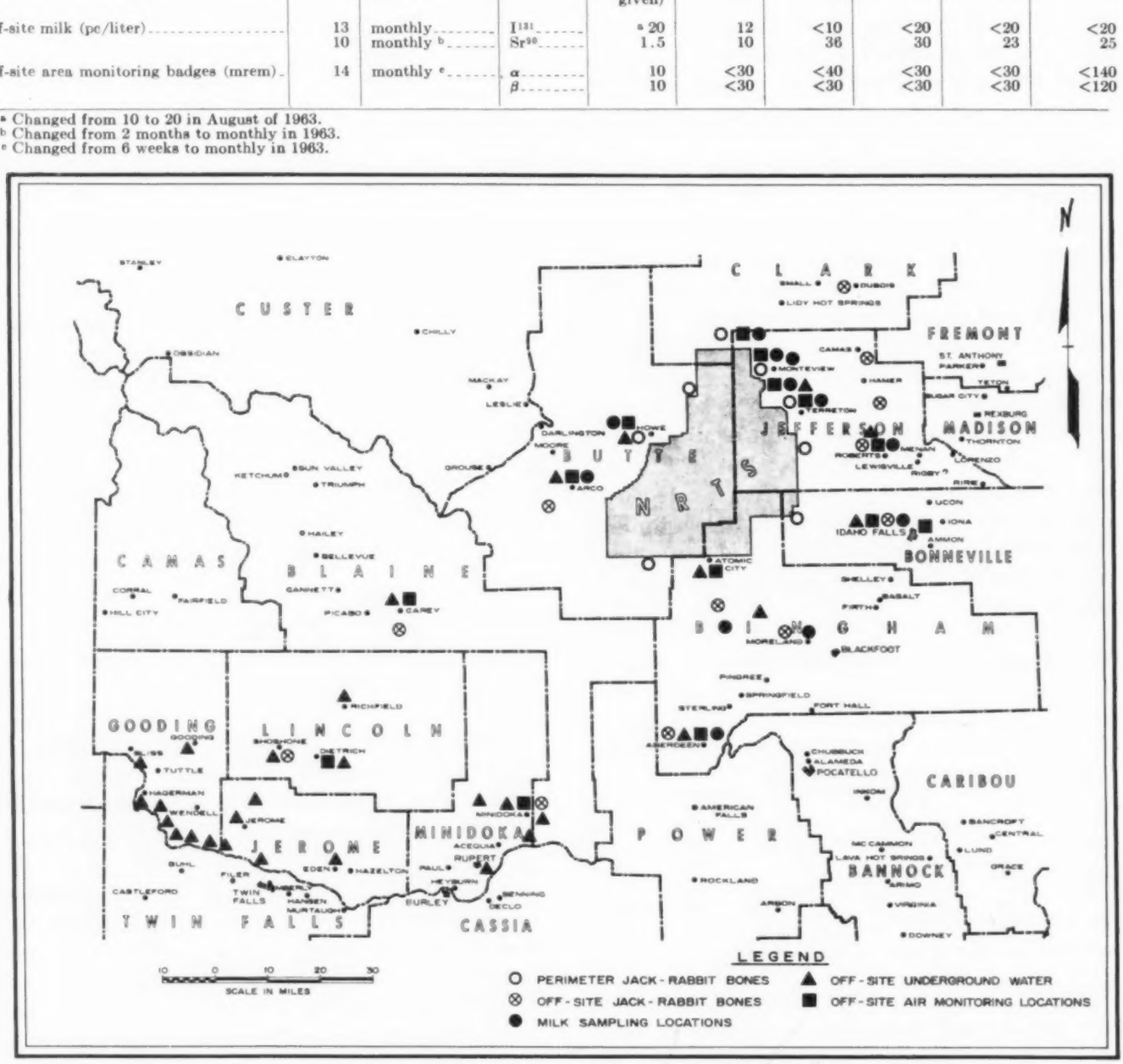

FIGURE 2.—ENVIRONMENTAL MONITORING STATIONS, NATIONAL REACTOR TESTING STATION

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*May 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters and calendar year 1961	*June 1962*
Calendar year 1962	*June 1963*

3. PINELLAS PENINSULA PLANT
Calendar Year 1963

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant shown in figure 3, is an electronic component production facility in the Atomic Energy Commission's Albuquerque Operations Office manufacturing complex. Environmental monitoring includes sampling of a single combined sewer effluent, milk from five local dairy farms, air, and surface water obtained at locations suggested by meterological conditions and radioactivity discharge concentrations. Except for air samples which may contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air Monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack, where maximum ground level concentrations would be expected. During the entire year, air sample analyses revealed no detectable concentrations of tritium gas (<1,300,000 pc/m³ of air)* or tritium oxide (<5,000 pc/m³ of air).

Water Sampling

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. During the year, there were no detectable concentrations of tritium oxide (<120,000 pc/liter) in the 244 samples taken.

* Expressions in parentheses indicate limits of detectability in the respective environmental samples.

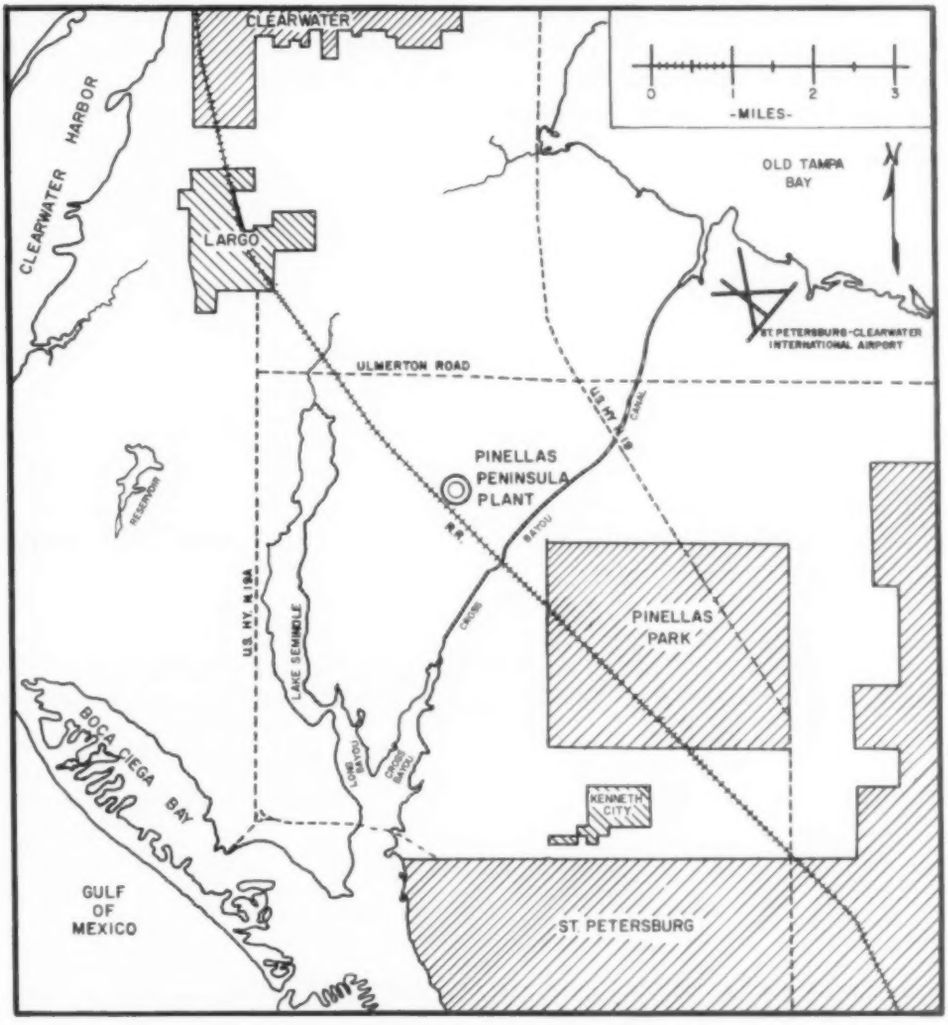

FIGURE 3.—LOCATION OF THE PINELLAS PENINSULA PLANT SITE

Surface water samples are normally obtained during the last week in each month at locations within 6 miles of the plant. These points are determined by radioactivity discharges in the exhaust stack effluent and meteorological data. In the event of accidental discharge of significant amounts of tritium, samples are obtained at the point of maximum ground deposition during or immediately following such discharges. There were no indications of tritium in 100 surface water samples analyzed during the year.

Milk Sampling Results

Forty-four samples of raw milk were taken from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1963. No detectable concentrations (<120,000 pc/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960–1961	*July 1962*
Calendar year 1962	*June 1963*

REPORTED NUCLEAR DETONATIONS, AUGUST 1964

During August 1964 three underground nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. Tests conducted on the 19th, 22nd, and 28th of the month were of low, low intermediate, and low yields, respectively, and were assigned *RHD* reference numbers 163–165 in chronological order. (Low yield is defined as equivalent to less than 20 kilotons of TNT; low intermediate yield is equivalent to from 20 to 200 kilotons of TNT.)

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September 1964

UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc =10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
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Honorable Stuart Symington
United States Senate
U S Capitol Rm 463
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